Materials in Design Engineering

FORMERLY
MATERIALS
& METHODS

SELECTION & USE OF METALS, NONMETALLICS, FORMS, FINISHES

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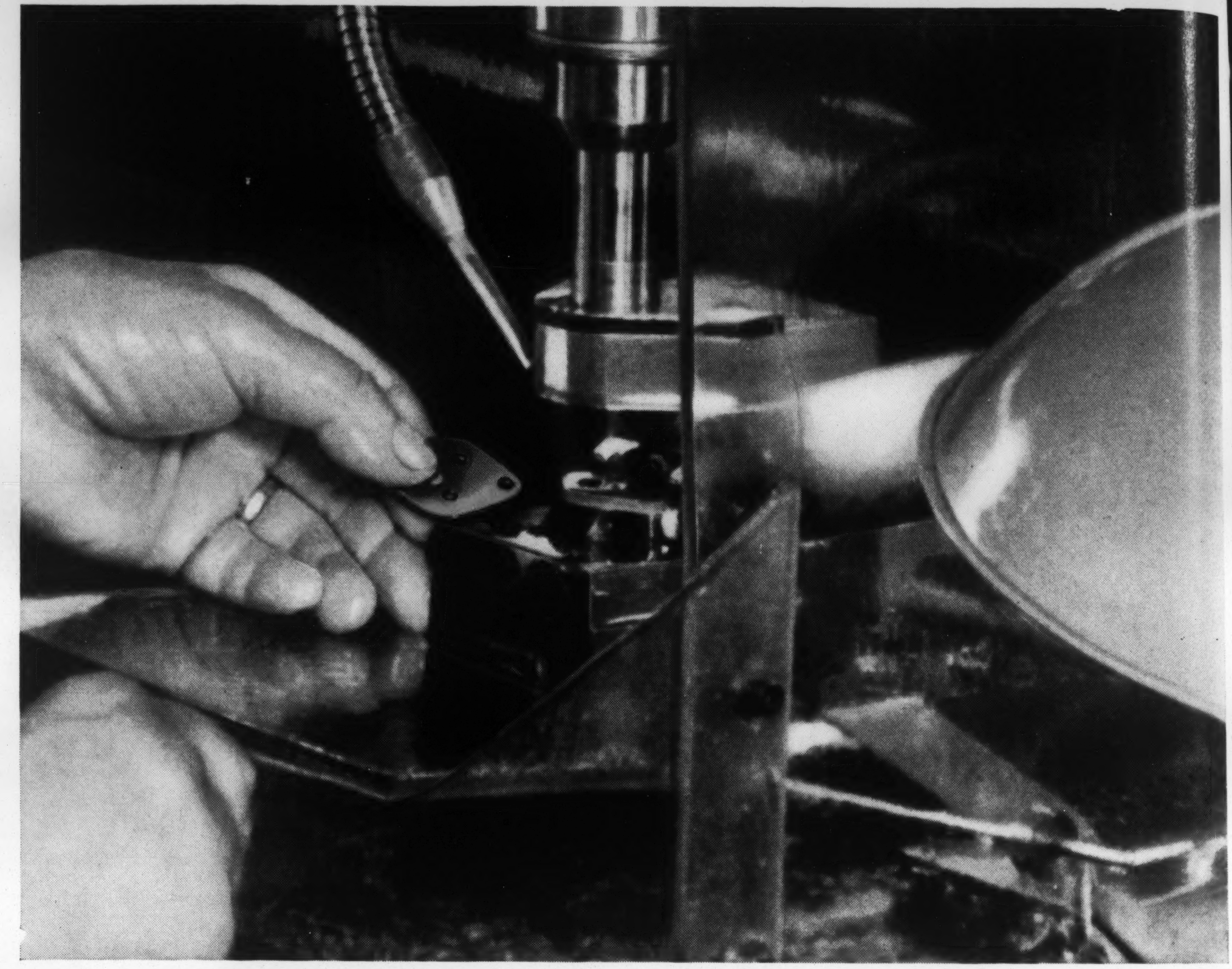
**Aluminum
Alloy
Castings**

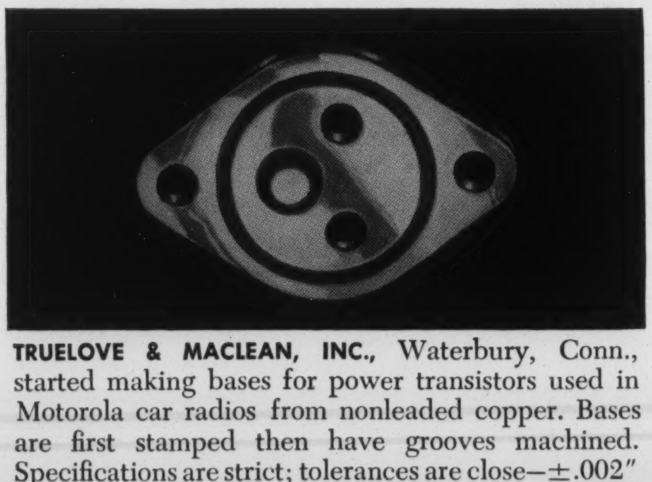
Manual No. 146
Also: New Cermets
Selecting Resistance Alloys
Complete Contents—page 1

ARY, 1958



MACHINING HIGH-PRECISION GROOVE in power transistor bases was easier and faster when Truelove & Maclean, Inc., switched to Anaconda Leaded Copper-126 in strip form.

High machinability plus high electrical conductivity with Anaconda Leaded Copper—now in strip form, too!



TRUELOVE & MACLEAN, INC., Waterbury, Conn., started making bases for power transistors used in Motorola car radios from nonleaded copper. Bases are first stamped then have grooves machined. Specifications are strict; tolerances are close—±.002″ on diameter of groove and ±.003″ on most other dimensions. Tool cost was high—production slow. They were faced with the necessity of buying additional equipment to meet daily production schedules. An American Brass representative studied the problem, suggested Anaconda Leaded Copper Strip. The results: tool life increased 10 times; production was speeded 25%; over-all costs went down 25%—plus greater accuracy.

When you have to do complicated or precision machining on parts requiring high electrical properties, Anaconda Leaded Copper-126—now available in strip form—can save a lot of trouble and expense.

High machinability. Anaconda Leaded Copper Strip machines almost as readily as Free Cutting Brass. It has a machinability rating of 80%, compared with 20% for nonleaded copper. This means faster production and longer tool life—greater latitude in design.

High conductivity. Anaconda Leaded Copper Strip has an approximate electrical conductivity rating of 99% IACS.

Get in touch with your American Brass Company representative for details of widths and thicknesses available. Or write: The American Brass Company, Waterbury 20, Conn.

5775

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Materials
in Design Engineering® *formerly Materials & Methods*

Selection & use of metals, nonmetallics, forms, finishes

FEBRUARY 1958 **VOL. 47, NO. 2**

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COVER BY HARRY & MARION ZELENKO

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This periodical is indexed regularly in the Engineering Index and the Industrial Arts Index

New light on how nickel reduces corrosive attack by fast-moving chlorinated solvents

Most chemical processors know that dilute HCl formed by decomposition of chlorinated solvent-water mixtures corrodes steel much more readily than Nickel.

But it's not so widely known that in Nickel equipment there is less hydrolysis of solvent . . . less formation of HCl to cause damage.

National Aniline puts this Nickel extra to good use in making diisocyanate

From the time diisocyanate is formed in a Nickel-clad reactor at National Aniline's Moundsville, W. Va. plant, the product touches no metal other than Nickel. Tanks are Nickel. Miles of tubing. Pumps. Cast fittings.

Here in the photograph is just *one* example. It's a sight-flow indicator with cast Nickel body. Based on corrosion to date, this cast Nickel body is expected to last ten years or more despite location of the indicator in a return line carrying fast-moving chlorinated solvent, phosgene, and the troublesome dilute HCl.

Jacoby-Tarbox Corp. had Inco cast the body parts for this sight-flow indicator

In producing sight-flow indicators, pressure tightness and strength are all important. Gasketing, glass seal, and castings must meet high specifications and close tolerances.

Consequently, Jacoby-Tarbox has Inco cast the body of indicators that will be used in lines carrying corrosives. Inco is a primary source for Nickel and its alloys and the Inco foundry has long experience in casting these materials.

What can you expect from cast Nickel?

An Inco phamphlet, "Engineering Properties of Cast Nickel" answers this question in detail . . . covering compositions, physical constants, hot hardness, mechanical properties, much more. Send for your copy.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N.Y.

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TRADE MARK

INCO-CAST PRODUCTS

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What's new IN MATERIALS

...AT A GLANCE

LARGE STEEL FORGINGS WITH IMPROVED DUCTILITY and crack resistance are now being produced by vacuum casting the metal before forging. Preliminary tests indicate that the castings, which are processed into huge turbine and generator shafts, are superior in quality to those produced by conventional casting methods. According to the producer, ingots up to 95 in. in dia and weighing 360,000 lb are vacuum cast in a chamber 17 ft in dia and 30 ft high.

OZONE RESISTANT NITRILE RUBBER, said to be the first nitrile to resist ozone cracking, is now commercially available. The producer says compounds can be made which are "unaffected by ozone during an extended test period, even when the compounds are soaked in hot oil before exposure to ozone." Other features: good oil resistance, good flexibility, high strength, and good abrasion and oxidation resistance. The material is suitable for electrical insulation and fabric coatings in both indoor and outdoor use.

HIGH STRENGTH STAINLESS STEEL CASTINGS, available in the form of valves and fittings, are said to have yield strengths of 22-27,000 psi at 650 F. Yield strengths are said to surpass the minimum yield strengths required by ASME for cast and forged type 304 stainless steel—18,400 psi for cast and 17,900 psi for forged. The castings are presently being used in nuclear reactors. (See article in next month's issue for further details.)

PAPER WITH AN INK SUPPLY BUILT INTO IT may someday be used as a "chemical memory system" in computers capable of recording an entire book on a square foot of paper. Basically, the memory system consists of paper coated with microscopic, dye-containing cells that change color when exposed to different wavelengths of light. It is believed that the chemical memory system will be able to remember information at considerably less cost than present electronic systems.

A NEW PRECIPITATION HARDENABLE STAINLESS STEEL, developed for airframe and skin applications in supersonic aircraft, is now commercially available in wrought and cast forms. The alloy, a modified chromium-nickel steel containing copper, molybdenum and titanium, has a coefficient of thermal expansion comparable to that of low carbon steel and considerably lower than that of 18-8. It has good resistance to acids and saline solutions, and it is said to have excellent resistance to stress corrosion cracking. (See article in next month's issue for further details.)

A SILICONE RUBBER ADHESIVE has been developed to bond vulcanized silicone rubber parts to themselves and to metal. The material is translucent and nontoxic, contains no solvent, and may be applied with a knife or a spatula. Cured films are said to have a tensile strength of 25 psi and to retain their strength and resilience at temperatures from -70 to 500 F. (More details next month.)

STRONGER FERROUS METAL POWDER PARTS than presently available are said to result from a new powder metallurgy technique. Although details of the process have not yet been released, the producer says ". . . the process converts inexpensive raw materials into a wide variety of high density iron alloy compositions by a single pressing and sintering operation." The process may eventually replace costly machining methods in the production of high strength gears, cams, levers, pawls and ratchets.

CLEAR HIGH DENSITY POLYETHYLENE FILM, almost as transparent as cellophane, is now commercially available. Chief property of the new film is its excellent resistance to moisture vapor transmission—said to be about four times that of low density polyethylene film. One immediate use is expected to be in food packaging.

NEW DEVELOPMENTS IN TITANIUM: 1) Spherical vessels measuring 16 to 25 in. in dia and made of 6 Al-4 V titanium alloy are now being produced by hot spinning instead of drawing. The spinning method is said to be cheaper and easier to control than deep drawing methods. 2) Titanium metal has no harmful effect on the long term storage life of lubricants, recent Army tests show. The tests confirm the fact that "most bearing metals except titanium act as catalysts in accelerating oxidation and chemical decomposition of lubricants."

A NEW PLASTICS TOOLING METHOD, based upon an epoxy resin system reinforced with metal or glass fibers and metal fiber flocking, is said to permit runs of up to 150,000 soft metal stampings. The epoxy composition has good thermal conductivity, high heat resistance and high impact strength; it can be repaired by a plug method, can be easily machined, and can be made magnetic. (More details next month.)

Turn to page 153 for more "What's New in Materials"

MATERIALS BRIEFS

Elephants May Live Longer

Chessmen said to have the feel and appearance of ivory are now being molded out of plastics. White chessmen are molded of melamine resins whereas red and black pieces are molded of phenolic resins.

Atomic Blond

Newly developed blond glass fibers looking something like a woman's hair seem to be an effective heat transfer medium in nuclear reactors.

oOO-Rings

Stainless steel o-rings with good sealing characteristics at high temperatures are obtained by filling the rings with gas at pressures ranging from 500 to 3000 psi. The internal gas pressure is said to offset the loss of the metal's strength at high temperatures.

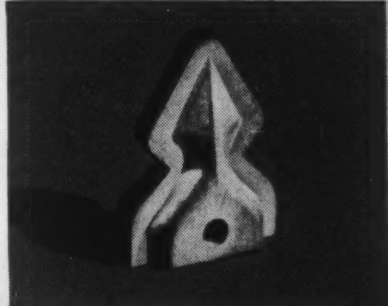
Vinyl Clad Pool

A self-adhesive vinyl film is being evaluated for possible use as a swimming pool lining. According to the producer, such a pool lining would have the advantages of complete water tightness and a durable, scratch-free surface.

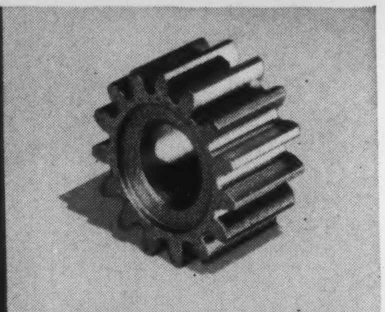
Home in a Dome

Marines will soon be pitching geodesic domes of vinyl coated nylon fabric over a framework of aluminum. The domes, slated to replace all of the tents now being used by the Aviation Branch of the Marine Corps, are said to weigh about one-fourth as much as ordinary shelter materials.

HOW CAN BRASS POWDER METALLURGY CUT COSTS FOR YOU?



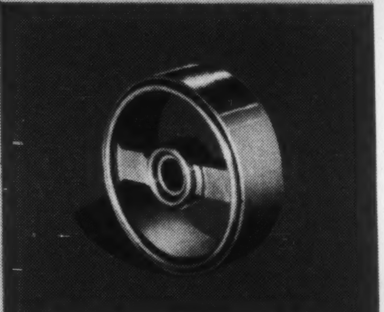
BRASS POWDER FINGER GRIP FOR SORTING MACHINE



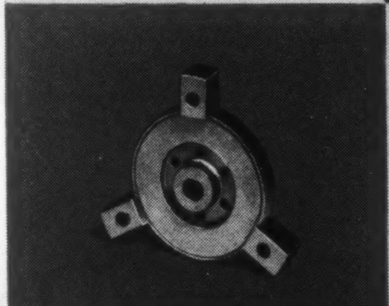
BRASS INFILTRATED GEAR FOR WASHING MACHINE

BRASS POWDER
Serves in Many Ways
Saves in Many Ways

- STRUCTURAL PARTS
- MECHANICAL PARTS
- INFILTRATED PARTS



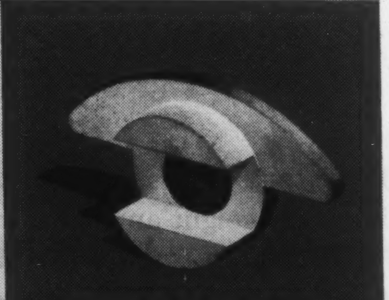
BRASS POWDER VALVE SEAT FOR PNEUMATIC DEVICE



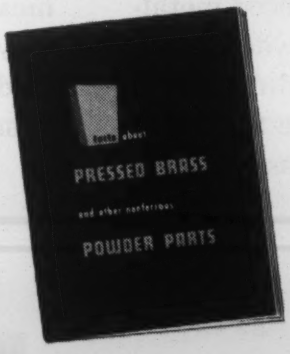
BRASS INFILTRATED PART FOR COMPRESSOR UNIT

high speed production
accuracy
low cost units
new design possibilities

BRASS INFILTRATED GUIDE FOR CABINET HARDWARE



BRASS POWDER HUB FOR LOCK HARDWARE



THIS BOOKLET will assist you in evaluating this modern production method in terms of your particular needs.

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160 Front Street, New York 38, N. Y.

HORSE HEAD PRODUCTS

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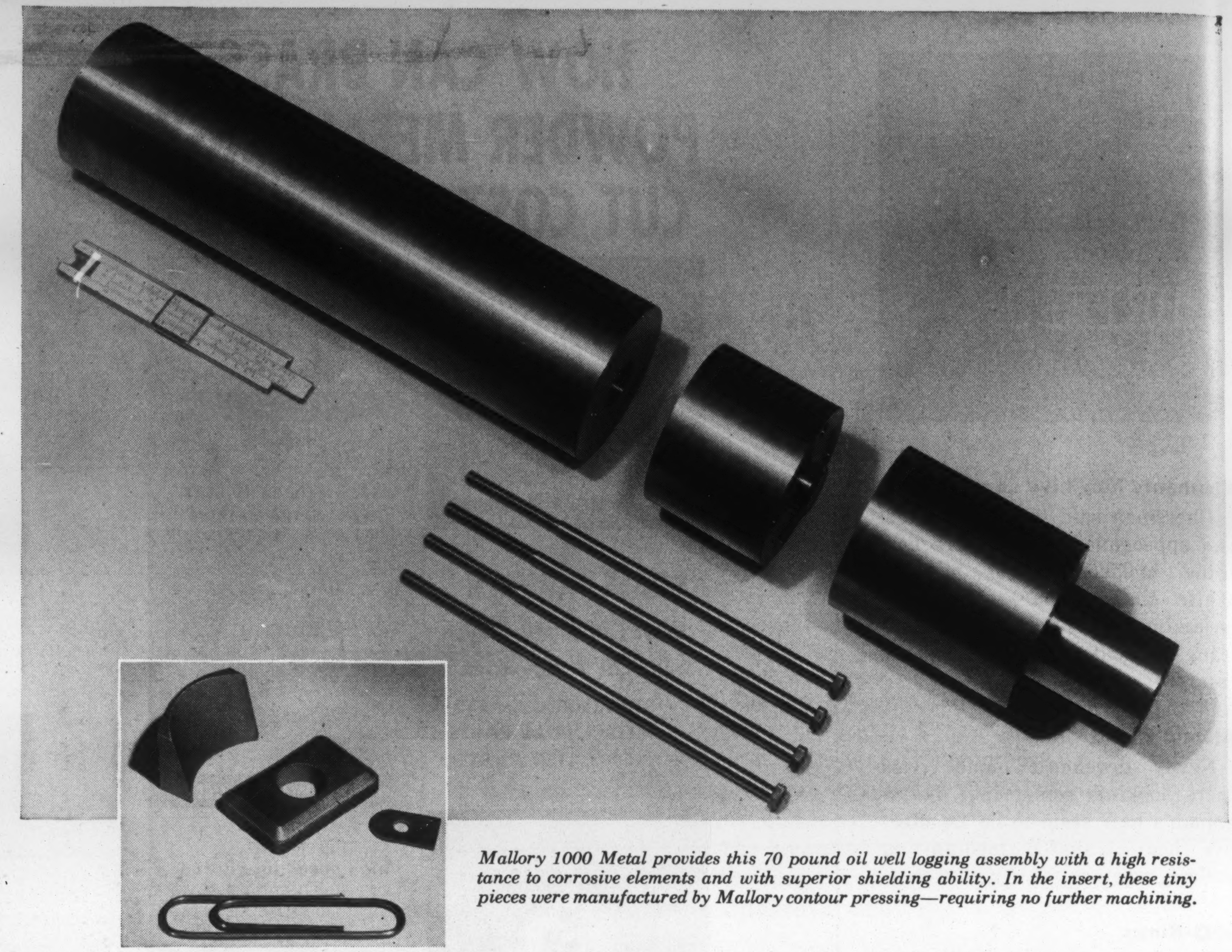

Mallory 1000 Metal provides this 70 pound oil well logging assembly with a high resistance to corrosive elements and with superior shielding ability. In the insert, these tiny pieces were manufactured by Mallory contour pressing—requiring no further machining.

Unique High-Density Alloy Solves Space Problems... at Low Cost

Mallory 1000 Metal is extremely versatile, capable not only of serving both weight and shielding requirements, but serving in big or little shapes with equal ease and efficiency. It can be economically contour-pressed into large or small, simple or complex shapes.

Mallory 1000 is a product of Mallory's advanced metallurgical engineering experience. It is a powder metal that can be compacted to close tolerances and machined to absolute precision—even to a high surface finish. Its density is 16.96 gm/cc . . . twice that of brass or steel . . . and is far stronger than lead.

Applications of this superior product include damping elements, small gyroscope rotors, counter-weights, gamma radiation shielding, and other such precision products.

Take advantage of Mallory's extensive background and experience in the field of special metals. Complete technical data and application information on Mallory 1000 may be had on request. A skilled engineering staff stands ready to serve as your consultant, no matter how large or small the part or the problem. Write today.

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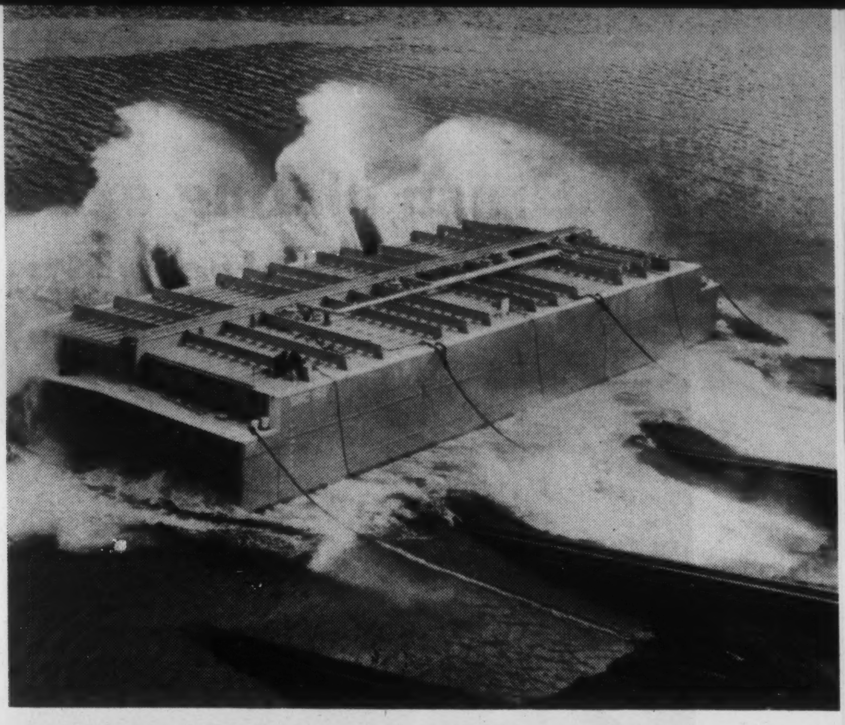
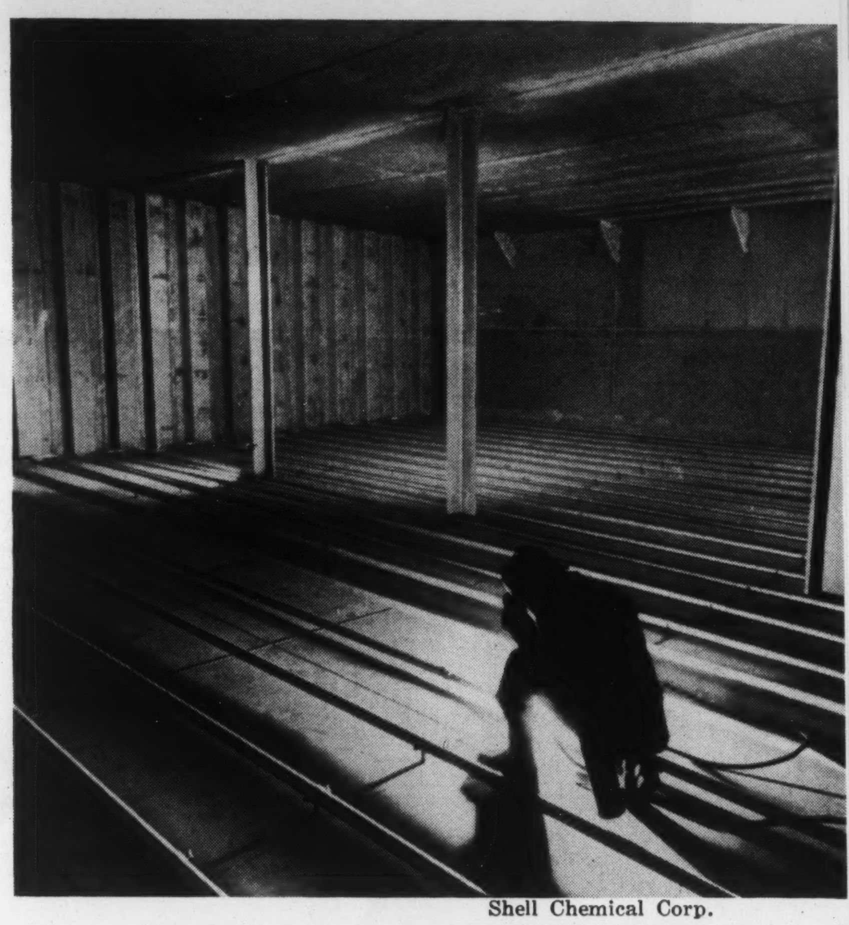
For information in titanium developments, contact Mallory-Sharon Metals Corp., Niles, Ohio.

For more information, turn to Reader Service card, circle No. 428

MATERIALS AT WORK

New and interesting applications of engineering materials





Shell Chemical Corp.

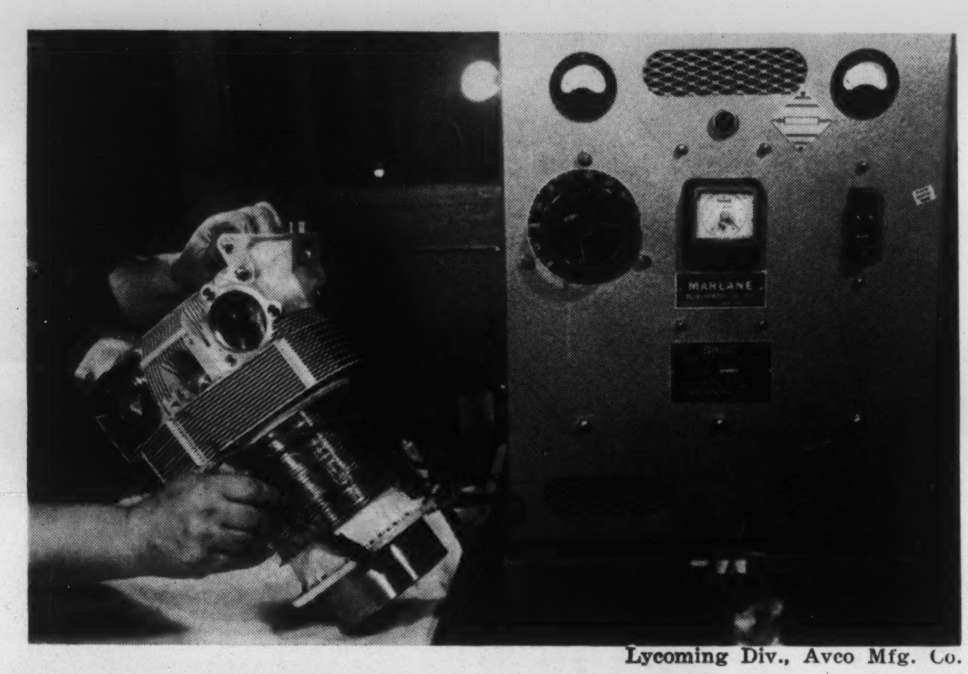
Nickel plated compartments keep chemicals pure in barge

Nickel plated steel compartments are making possible the first use of barges like the one shown above for the transportation of high purity chemicals. Previously, bulk shipment of such chemicals as glycerine and hexylene glycol was possible only in specially lined tank cars. The nickel plate protects the chemicals from iron contamination.

The barges are of double-skinned construction—a hull within a hull. The inner hull of nickel plated compartments is formed by welding plates of Colorado Fuel & Iron Corp.'s Lectro-Clad nickel plated steel into tank-like sections (see photo below).

The barge shown here measures 135 ft long, 50 ft wide and 14 ft, 6 in. deep, and has a capacity of 15,000 barrels. Steel girders normally placed on the underside of the deck, have been placed on top of the deck, thereby leaving all compartments relatively free of internal obstructions.

Brush plating extends usefulness of the electroplating process in . . .

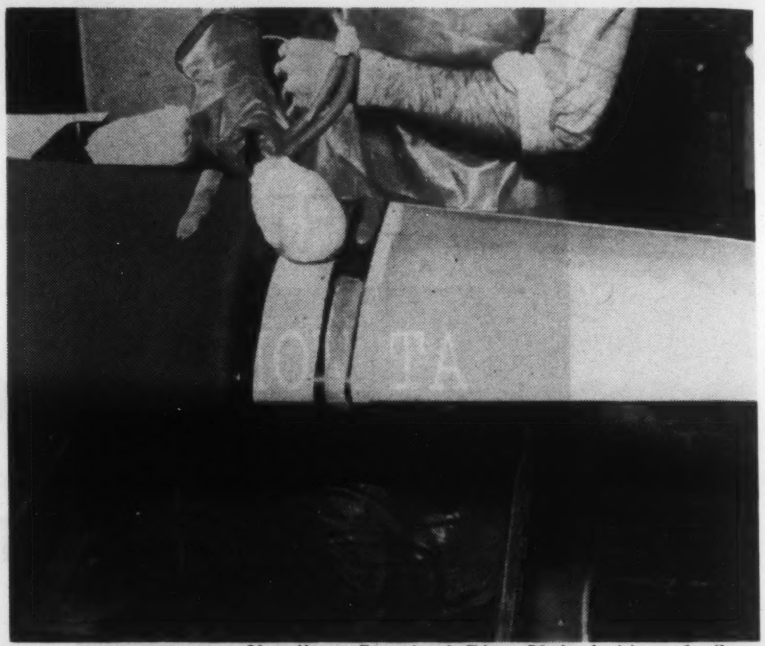


Lycoming Div., Avco Mfg. Co.

Build-up and repair. *Because slight nicks or scratches in sprayed aluminum coating would permit corrosion of steel cylinder barrel, such areas are plated with cadmium.*

Marlane Development Co.

Improving wear resistance. *To improve wear resistance and electrical conductivity of the sliding contacts in this printed circuit, they are brush plated with 0.15 mil of gold, followed by 0.05 mil of rhodium.*



Hamilton Standard Div., United Aircraft Corp.

Selective plating. *A zinc coating is brushed on a section of aircraft propeller immediately adjoining a rubber fairing. Fairing could not be immersed in plating bath because trapped solution might later cause corrosion.*

Close specification work. *To achieve a perfect, vibration-free fit for a bearing, this housing is brush plated with 0.2 to 0.5 mil of tin.*

Lycoming Div., Avco Mfg. Co.

Touch-up work. *Small recessed areas in crankcase of engine, sometimes shielded during conventional plating, are easily touched up with brush plated cadmium.*

Extending service life. *Conventional commutators in aircraft pump motors wore badly after only 10 to 365 hr, resulting in excessive current draw and radio interference. Brush plated with rhodium it maintained perfect efficiency for more than 1200 hr.*

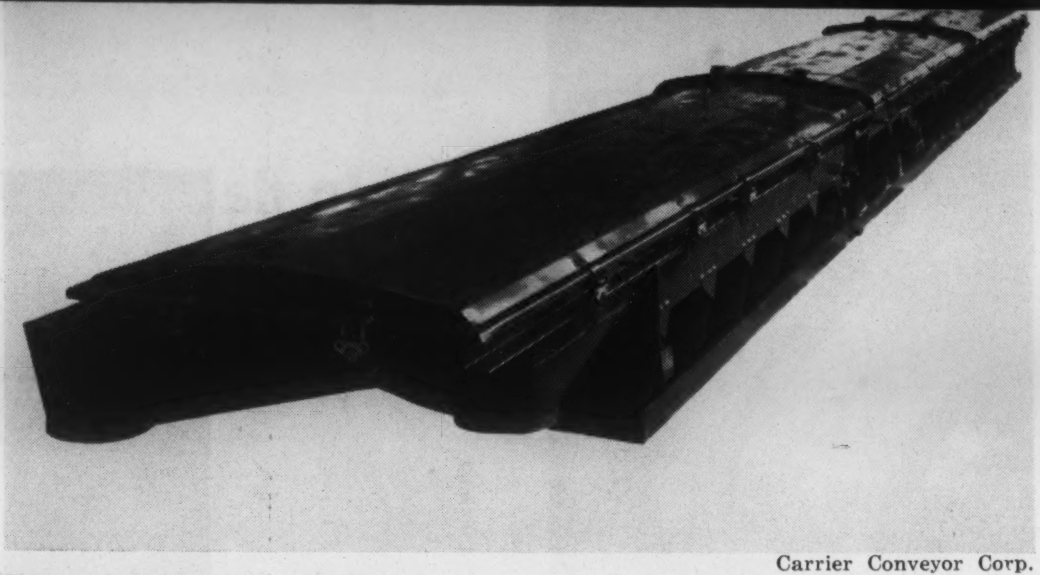
■ Within the last few years brush plating has developed from a "touch-up" method to an important plating technique with broad application. Originally developed in France and now available in this country, the brush plating process has become increasingly valuable for applications in which 1) only selected areas of a part require plating, 2) parts would have to be disassembled if bath plating were used, 3) deep holes or corners have to be plated, 4) dimensional tolerances are extremely close, 5) absence of stress or hydrogen embrittlement is significant, 6) consistently high purity deposits are required, or 7) the metal to be plated is attached to a material that cannot be immersed in a plating bath.

The process

Brush plating, or the Dalic Process, developed by Dalic Metachemical, Ltd., is an electrodeposition process in which the electrolyte is brought to the part, completing an electrical circuit. This is done by soaking a pad in an appropriate plating solution, making the pad anodic, and manually rubbing or brushing it over the surface to be plated which is made cathodic. The anode is composed of a stylus and a high purity graphite rod wrapped in an absorbent material — usually long fiber cotton, filter paper or felt. A special rectifier, one of the principal components of the plating equipment, has a finely graduated ampere-hour meter which shows the amount of deposit. As a result, thickness can be controlled to within 0.0001 in. (For further details, see MATERIALS & METHODS, Dec '54, p 98.)

Applications

Practically any plating metal or solution can be used in the process, including chromium, copper, gold, lead, nickel, silver, tin and zinc. Some of the most common uses are shown on these pages.



Carrier Conveyor Corp.

Natural frequency vibrating *conveyor is mounted on cantilever-type leaf springs made of glass-reinforced epoxy.*

Glass-Reinforced Epoxy Springs Offer Strength, Energy Absorption

High energy absorption characteristics, strength, excellent resistance to chemical fretting and corrosion, and ease of fabrication are the main reasons given for the selection of fibrous glass-reinforced epoxy for the cantilever-type leaf springs used on Carrier Conveyor Corp.'s "natural frequency" vibrating conveyors.

Although use of reinforced plastics as a spring material is not entirely new, the development of glass-epoxy springs is significant because they are said not only to be more efficient than steel springs, but to have a much greater service life than other reinforced plastics types.

Why reinforced epoxy?

Actually several materials were tested: steel was found to be impractical because its modulus of elasticity was too low; phenolic-impregnated plywood was found to buckle after exposure to moisture; and glass-reinforced polyester springs cracked after a few hours (see photo on p 196). The glass-epoxy material ("Scotchply") not only satisfies all of the requirements of strength and energy absorption, but has an added advantage: the glass filaments can be specifically oriented (either uni-

(continued on p 196)

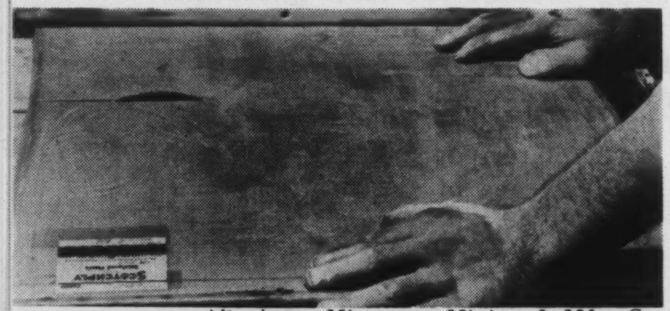
Natural Frequency Vibration

Natural frequency is defined as the free vibration of an elastic system. When an external force is applied in resonance with the natural frequency of any vibrating system, extremely large amplitudes of vibration quickly occur and, once started, can be easily maintained by very small exciting forces.

A vibrating conveyor is merely a trough mounted on leaf springs at approximately 60 deg to the horizontal. When the trough is put into motion at a frequency coinciding exactly with the natural frequency of the trough and spring system, motion is at an angle perpendicular to the flexible support provided by the springs. However, each part of the trough duplicates the reciprocating straight-line motion at an angle of 30 deg to the horizontal. As a result, the loose, granular bulk materials, such as sand, detergent powder, and chemicals which the conveyor best conveys, are thrown upward and forward.

Once the trough is vibrating, the springs alternately absorb and give back the same energy; actually they return approximately 90% of the energy absorbed.

Glass-epoxy springs are easy to fabricate



All photos Minnesota Mining & Mfg. Co.

1. *Strips are cut* *to size from large sheet of reinforced epoxy.*

2. *Holes are drilled* *for fastening springs to conveyor.*

3. *Completed springs* *measure 5 1/2 by 19 by 5/16 in. thick.*

MATERIALS AT WORK

New Economy and Speed in Tooling Production for the Airframe Manufacturer with POLYTOOL

Photos courtesy of Arrowsmith Plastic Tooling, Inc., Los Angeles, Calif.

RCI EPOXY PLASTIC TOOLING COMPOUNDS

In the photos above you see a completed plastic stretch die and the laminating build-up stage in its fabrication.

This plastic stretch die has excellent dimensional stability. It is lightweight and was produced fast at low cost.

Reichhold, a basic manufacturer of resins, offers you a full line of epoxy plastic compounds for tool production.

POLYTOOL 2501 (white finish) and **2551** (metallic) are epoxy plastic tooling compounds for casting and laminating applications.

POLYTOOL 2502 (white finish) and **2552** (metallic) are epoxy plastic tooling compounds for gel coat application.

Reichhold supplies low irritation **POLYTOOL HARDENERS** for varying the gel time of these compounds. Reichhold also furnishes POLYTOOL compounds for a 3-component system with which you can vary working properties to meet specific requirements.

Why not investigate the **RCI POLYTOOL** line of plastic tooling materials? It includes not only epoxy, but also polyester, phenolic and polyurethane resin systems. RCI offers you outstanding quality control of these materials.

REICHHOLD

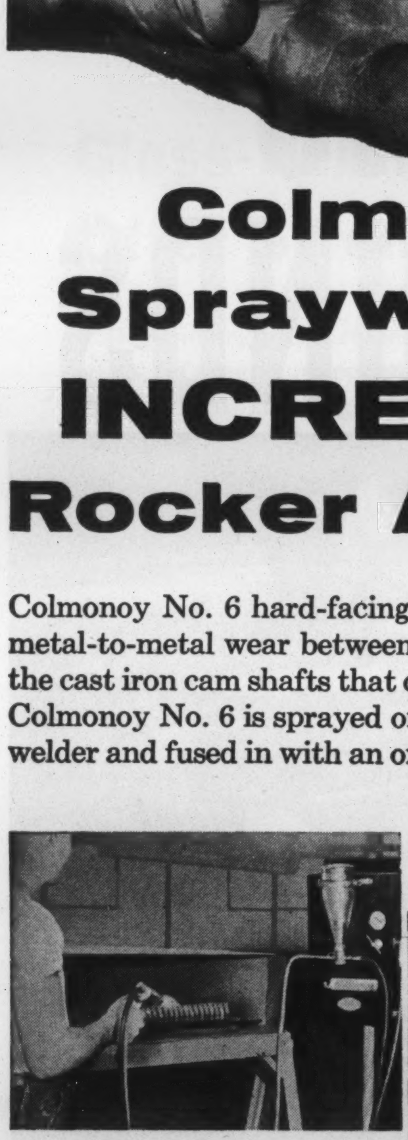
Synthetic Resins • Chemical Colors • Industrial Adhesives • Phenol
Hydrochloric Acid • Formaldehyde • Glycerine • Phthalic Anhydride
Maleic Anhydride • Sebacic Acid • Ortho-Phenylphenol • Sodium Sulfite
Pentaerythritol • Pentachlorophenol • Sodium Pentachlorophenol
Sulfuric Acid • Methanol

REICHHOLD CHEMICALS, INC.,
RCI BUILDING, WHITE PLAINS, N.Y.
Creative Chemistry... Your Partner in Progress

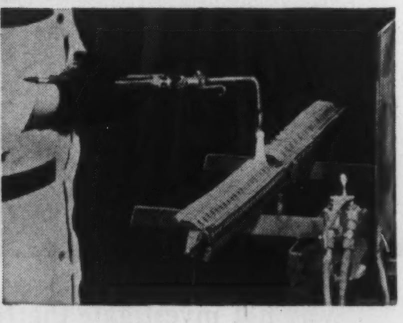
For more information, turn to Reader Service card, circle No. 431

Colmonoy Spraywelding INCREASES Rocker Arm Life

Colmonoy No. 6 hard-facing alloy stopped the excessive metal-to-metal wear between the rocker arms shown and the cast iron cam shafts that operate them. Wear resistant Colmonoy No. 6 is sprayed on with the Colmonoy Spraywelder and fused in with an oxy-acetylene torch.



After spraying, the overlay is fused to the base metal.



Rocker arms being sprayed with the Spraywelder.

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Letters to the Editor

Forming by grinding

To the Editor:

We read with great interest your article on p 120 of the Oct '57 issue, "Designing for Screw Machine Parts." We are trying to prepare a folder which will describe the centerless grinder with a crush formed face being used as a screw machine. No doubt your reference to centerless grinding was as a secondary rather than a primary operation. We would like to prove that you can design to form by grinding. We have seen studs recessed on centerless grinders to almost ⅛ in. by the in-feed method at the rate of 200-300 per hr. No doubt if the feeding mechanism were automatic, this could be brought to three or four times that rate, and if through feed could be used, the rate could be 20 to 30 times.

The screw machine people, being jobbers, are not in a position to educate the designer to the economy of forming his piece by grinding. However, magazines such as yours should be excellent avenues for such discussion.

Would you please send us a dozen reprints of any articles you have printed on this subject of designing for grinding?

W. S. Netter
Director of Manufacturing
Keystone Abrasive Wheel Co.
Carnegie, Pa.

We have no information on the use of centerless grinding as a primary operation. Such an article, using the same approach as the screw machine story, would certainly be welcomed for consideration.

Gamma ray shielding

To the Editor:

My attention has been called to the letter of Mr. Robert Ziegfeld of the Lead Industries Assn. in the September issue of MATERIALS IN DESIGN ENGINEERING. I am surprised that you published the letter without comment since it contains two serious errors.

If it is the high density of lead that makes it so efficient for shielding, then why are not gold, tungsten, tantalum, platinum and iridium even more efficient, since they have higher densities? Actually, the high density is not the factor; it is rather the nature of the energy of the electrons.

So far, no other element or isotope has been found to compare with lead for gamma ray shielding, but, because of the great weight, it is impractical to use any great quantity of lead in aircraft, in submarines, or in the superstructure of ships. Much research is now underway on this problem, and the answer may possibly be found through the activation of the electrons of a light material by the introduction of small amounts of another isotope. At this

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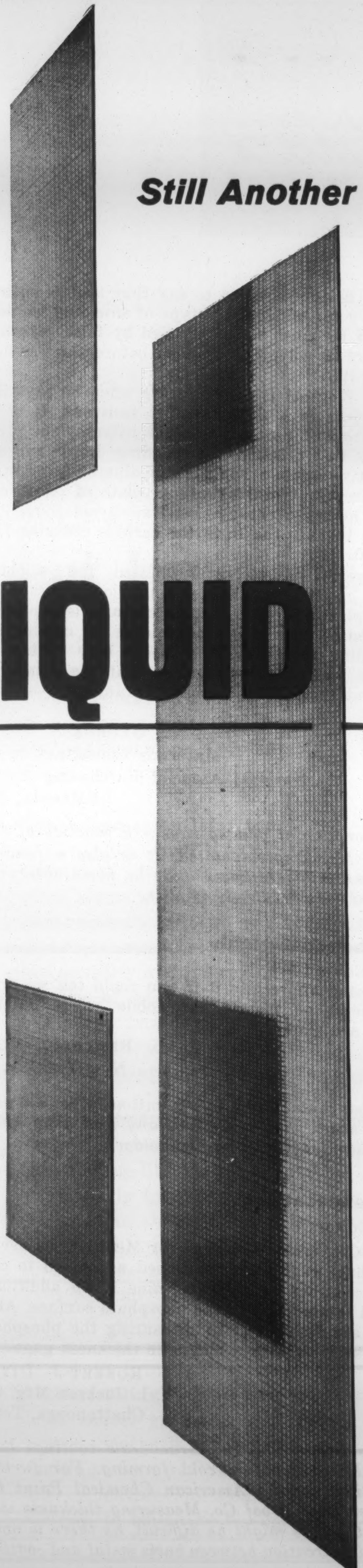

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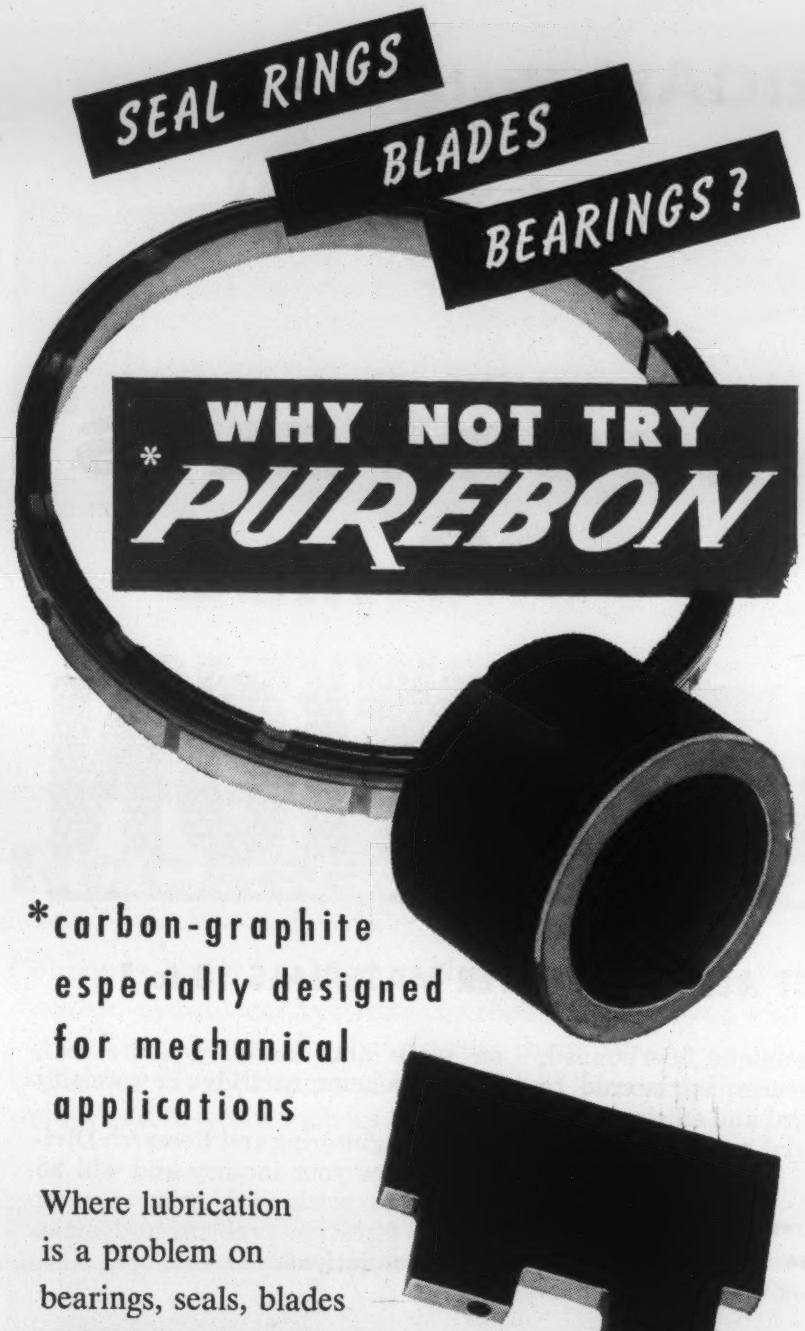

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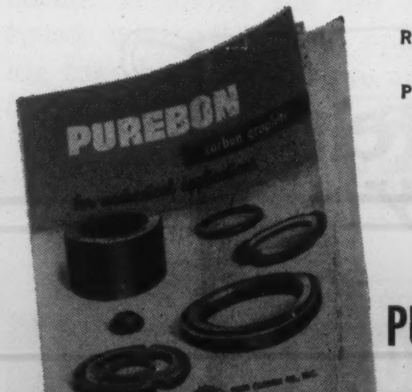

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Letters to the Editor

stage it is only possible to say that lead is entirely too heavy for much of the type of shielding we need, and that we must not be stymied by false reasoning if we are to solve the problem before the Russians do solve it.

Mr. Ziegfeld is also in error when he says that polyethylene is a shield against neutrons. It is the introduction of Boron-10 into the polyethylene plates or blocks that produces the shielding. Boron will also be effective against neutrons in aluminum or other materials. The Boral aluminum plate of Alcoa contains a high percentage of boron carbide, and it is effective because the B_4 in the carbide contains 12% Boron-10.

Polyethylene blocks *are* used for shielding against *gamma* rays, as you previously described, but the plastic for this purpose contains lead powder. It is used because of its convenience for casting and for welding together. Such blocks may contain as much as 95% lead powder, so that the density is high, and there is no weight advantage over lead metal.

GEORGE S. BRADY
Materials Consultant to the
National Assn. of Purchasing Agents
Bethesda, Md.

The absorption of gamma rays is a function of density, as Mr. Ziegfeld stated. It is also a function of the material thickness and the mass absorption coefficient, as Mr. Brady implies.

Wheel balance weights

To the Editor:

I would appreciate it if you could tell me from what metal or metals automobile wheel balance weights are made.

BERTOLD WOLFF
New York, N. Y.

Hard lead, containing 4 to 6% antimony, is generally used. A small shop might use any lead alloy available, which frequently means solder.

Phosphate coatings

To the Editor:

In "Conversion Coatings for Metals," the use of a phosphate surface is mentioned as an aid to cold forming, but we cannot determine if an additional lubricant is needed with the phosphate surface. Also, is there a suitable way of measuring the phosphate coating, such as with a magnetic thickness gage?

ROBERT J. DITTO
W. L. Jackson Mfg. Co.
Chattanooga, Tenn.

Both the Bonderlube and Granodraw coatings have to be lubricated before cold forming. For further information, contact American Chemical Paint Co. or Parker Rust Proof Co. Measuring thickness with a magnetic gage might be difficult, as there is not a distinct demarcation between basis metal and coating.

ONE POINT OF VIEW

We must teach more science, but how, and to whom?

Just about everyone now agrees that we need more and better science education and training. But the questions of who should be taught science and how it should be taught are still to be settled.

Teach non-scientists, too

The character of the recently announced Federal aid program seems to indicate that the Government's efforts will be directed largely at increasing the quantity and improving the quality of our scientists and engineers. This is probably the wisest approach to solving the short-term problem. But the long-term, and perhaps even more critical, problem is providing effective science education for the literate public, and particularly for our youth. As we tried to show on this page last month, only with the public's genuine understanding and consent can creative science advance and, indeed, survive.

Thus far our education has failed to provide this needed understanding. The average high school graduate and college student still knows little or nothing about real science and the scientific method. The courses to which he is exposed are usually either an assortment of unrelated facts or a description of the practical results of science. Insight and understanding are sacrificed to disconnected details, and theory and abstractions are avoided as being too difficult and uninteresting.

For true appreciation and understanding of science, practical or peep-show courses are not the answer. What is needed are skillfully planned courses that show the non-scientist what science and the scientific method really are. Such courses must demonstrate how science asks questions about the world; how it seeks the answers through observation, experiment and reasoning; and how scientific theories and laws are developed.

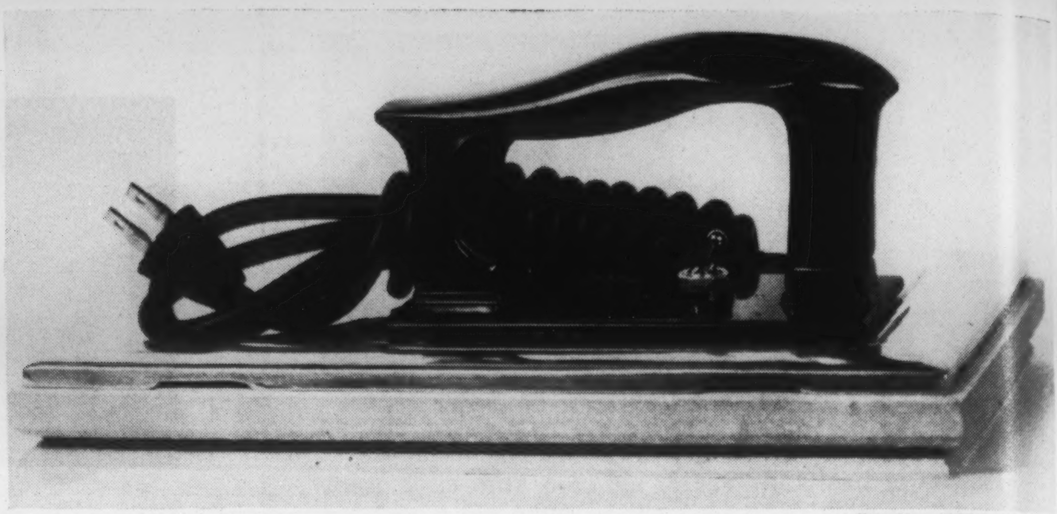
Ideas don't scare kids

Recent studies and experiences in teaching have shown that people, including children, do not vigorously dislike abstract thinking and theory, as is commonly supposed. Rather, most of us have an innate taste for abstract ideas. The University of Illinois Committee on School Mathematics reports that high school students, in particular, have a profound interest in ideas. They are speculative and, given the right courses, they enjoy working with abstractions.

Better courses needed

So, here is a challenge to education to cultivate this taste for scientific ideas. It is not easy, but it can be done. An example of imaginative science teaching is a course given at Princeton University for non-scientists. Nicknamed the "block-and-gap" course, it concentrates on a small number of topics (blocks) that form a connected scheme or structure. By a thorough study of a few topics, the students learn and understand the function of theory and experiment; and they see how imaginative speculation and basic research lead to scientific advances. The many topics not covered (gaps) can be studied later in life by the student if he needs or desires them.

Many more courses like this will be required if we are to succeed in providing the non-scientist with a true understanding of science and the role it has come to play in our modern culture.



Sterling Mfg. Co.

Putty softener—*Nickel-chromium heating elements used in this 700-w unit are visible between two lower plates.*

Here are some typical uses ↑

How to Select a Resistance Heating Alloy

Five principal groups of resistance alloys are available for electrical heating. This article describes properties, costs and uses.

by Robert J. Fabian, *Associate Editor, Materials in Design Engineering*

■ A large number of electrical resistance alloys have been developed for heating elements and for resistance elements in electrical and electronic components. Of these, the number developed especially for heating purposes is comparatively small. The heating alloys can be classified into four principal groups as follows: 1) nickel-chromium, 2) nickel-chromium-iron, 3) iron-chromium-aluminum-cobalt (some of the newer alloys in this group do not contain cobalt), and 4) molybdenum disilicide.

Pure molybdenum wire and tungsten carbide are also used—to a lesser extent—in specialized high temperature applications. Because of its poor oxidation resistance molybdenum must be operated in pure hydrogen or dissociated ammonia.

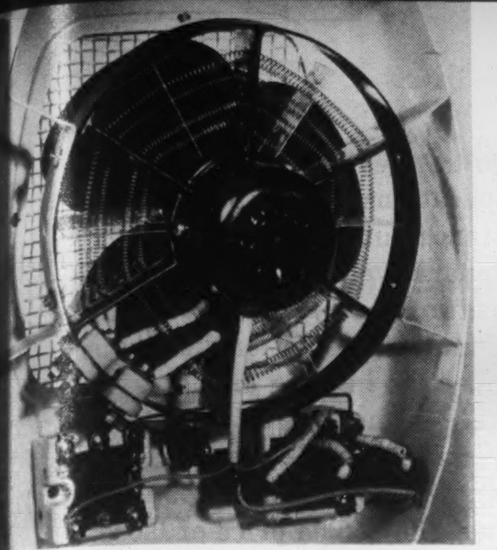
1. Nickel-chromium

Properties—Because of its excellent combination of electrical and mechanical properties, 80 nickel-20 chromium is probably the most widely used heating alloy. The alloy is highly resistant to oxidation and corrosion up to a maximum temperature of 2150 F.

In addition to its high resistivity (about 650 ohms per cmf) the 80 nickel-20 chromium alloy maintains a fairly constant resistance as temperature is increased. As shown by the graph on p 107, the resistivity of the alloy increases 7% from room temperature to 2000 F, depending on the wire size. Elements of small cross sectional area follow the maximum curve and larger size elements follow the minimum curve. In general, the resistance properties of wire between 0.0126 and 0.051 in. in dia and strip between 0.005 and 0.01 in. in thickness correspond to the average curve. This is the curve most commonly used for design calculations.

The nickel-chromium alloy possesses good resistance stability and remains ductile after long usage (thus permitting repairs to be made to elements). As shown in the accompanying table, the tensile strength of the alloy ranges from about 100,000 psi in the annealed state to 200,000 psi in the full hard or cold worked condition. In practice, the strength factor is not usually too important. Resistance elements are usually designed so that they are not stressed or loaded, and for this reason the alloy is most commonly specified in the annealed state.

Operating factors—In general, the nickel-chromium alloy is best suited for high temperature, heavy duty applications such as electric ranges, radiant heaters and electric furnaces. The material provides excellent performance and trouble-free service when operated in oxidizing and inert atmospheres and can be used with good results in properly controlled reducing atmospheres. It



Space heater—*Air blast keeps temperature of iron-chromium-aluminum-cobalt elements well below 1400 F.*

Glas-Col Apparatus Co.

Melting pot—*Nickel-chromium heating elements are used in this rugged 115-v pot to melt wide range of materials, including glue and asphalt.*

is especially important in controlled atmospheres to prevent overheating, even for short periods of time, as overheating can cause excessive carbon pickup and premature failure.

Excessive pickup of sulfur, lead, tin and zinc can also cause premature burn-out. Because of the presence of sulfur in oil, excessive oil should be removed from all work before it is heat treated, and new furnaces should be heated under oxidizing conditions when starting up to remove any excess sulfur.

Under certain conditions of atmosphere and temperature the 80 nickel-20 chromium alloy is subject to rapid corrosion and failure. This type of failure is generally encountered in an atmosphere that is partially reducing and in a temperature range of 1600 to 1800 F. A partially reducing atmosphere would be one that oxidizes chromium and reduces nickel.

Failure under these conditions is called "green rot failure" and is characterized by a brilliant green spongy oxide on the wire surface. This oxide is largely composed of chromium oxide and produces reduced strength and corrosion resistance.

In applications where the above atmosphere and temperature combination must be used, a special 80 nickel-20 chromium alloy stabilized with columbium has been used with good results. Also, where high temperature strength is not too important, it may be necessary to switch to a 35 nickel-20 chromium alloy.

Cost—In general, the cost of the 80 nickel-20 chromium alloy is somewhat higher than that of other resistance alloys. Choosing a standard size and form, say 0.032-in. (No. 20 B&S) bare wire, the cost of the material is roughly $4.21 per lb.

2. Nickel-chromium-iron—I

Nickel-chromium-iron alloys can be subdivided into two principal groups which differ principally in their ratio of nickel to chromium. The first group consists of alloys containing 60 to 62% nickel, 15 to 16% chromium and the balance iron. Content of the second group is quite different: 35% nickel, 18 to 20% chromium and the balance iron.

PROPERTIES OF RESISTANCE HEATING ALLOYS

Alloy ➔	80 Ni-20 Cr	60 Ni-16 Cr-Bal Fe	35 Ni-18 to 20 Cr-Bal Fe	22 Cr-5 Al-1 Co-Bal Fe	Molybdenum Disilicide
Max Operating Temp, F	2000-2150	1700-1950	1500-1800	2370	2900
Electrical Properties					
Resistivity (at 68 F), ohms/cmf	650	675	600	836	180 (approx)
Temp Coef of Resistivity, per °F	0.61×10^{-4} (68-932 F)	0.83×10^{-4} (68-932 F)	0.2×10^{-3} (68-932 F)	0.17×10^{-4} (68-212 F)	27×10^{-4} (68-2900 F)
Mechanical Properties					
Tensile Strength (68 F), psi					
Full Hard	200,000	175,000	150,000	105-120,000	—
Annealed	100,000	95,000	70,000	165,000	—
Elongation (annealed), %	25-35 (in 2 in.)	25-35	20-30	13-17 (in 10 in.)	4-5 (2820 F)
Reduction of Area (annealed), %	55	55	45	65-75	—
Hardness (annealed)	R_B 80-85	R_B 80-85	R_B 80-85	R_B 95-100	1200 Vickers
Physical Properties					
Specific Gravity	8.412	8.247	7.95	7.15	5.6
Density, lb/cu in.	0.304	0.298	0.287	0.258	0.212
Coef of Ther Exp, per °F	0.94×10^{-5} (50-1832 F)	0.94×10^{-5} (68-1832 F)	0.88×10^{-5} (68-932 F)	0.93×10^{-5} (68-1832 F)	0.5×10^{-5}
Approx Melting Point, F	2540-2600	2462	2516	2741	—
Specific Heat, Btu/lb/°F	0.104	0.107	0.110	0.115	—
Cost (0.032-in. wire), $/lb	4.21	2.93	2.39	2.84	—
Available Forms	Wire, ribbon, strip, rod	Wire, ribbon, strip, rod	Wire, ribbon, strip, rod	Wire, ribbon, strip, rod	Rod
Typical Applications	Furnaces, ranges, heaters	Domestic heating appliances	Industrial heating equipment	Appliances and industrial heating equipment	Industrial heating equipment

Properties—As shown in the accompanying table, the maximum operating temperature of the 60 nickel-16 chromium alloy is roughly 300 °F lower than that of the 80 nickel-20 chromium alloy. Resistivity of the material is about 675 ohms per mil, and tensile strength varies from 95,000 psi in the annealed condition to 175,000 psi in the full hard condition. The effect of increasing temperature on the resistivity of the material is shown in the graph (p 107).

Operating factors — The 60 nickel-16 chromium alloy was developed primarily to satisfy the requirements of a wide range of applications where temperatures do not exceed 1700 to 1950 F. It is used principally in low and medium duty domestic appliances such as irons, toasters, coffee makers, grills and roasters. It is also used extensively in industrial applications for rheostats and resistance units. Because of its comparatively low operating temperature and oxidation resistance, the material is not ordinarily used in electric heating furnaces.

Cost—The cost of 60 nickel-16 chromium alloy is somewhat lower than that of the 80 nickel-20 chromium alloy. The price of 0.032-in. bare wire is $2.93 per lb.

3. Nickel-chromium-iron—II

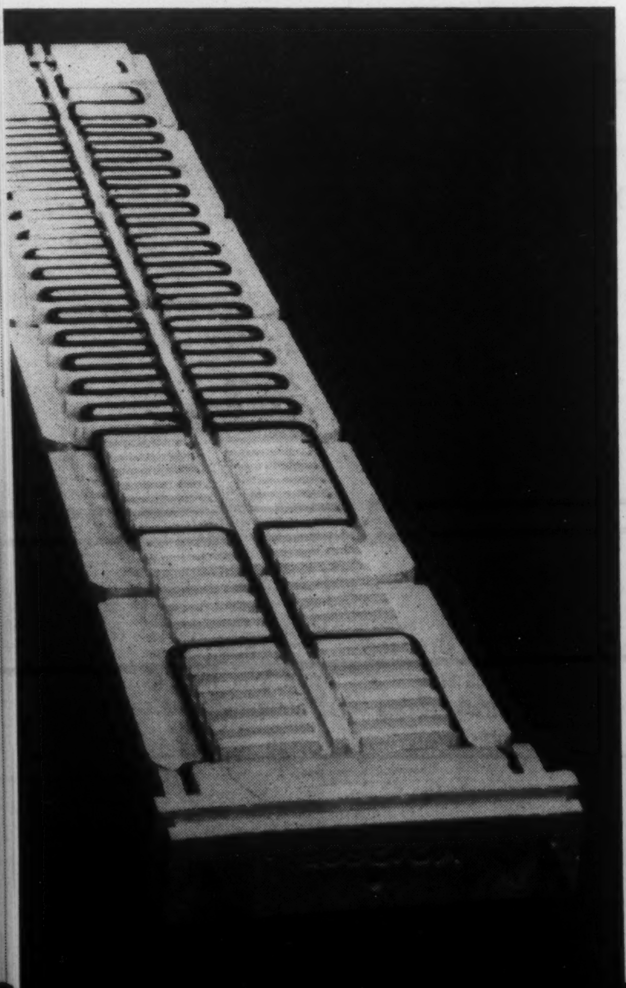
Properties — Alloys containing 35% nickel, 18 to 20% chromium and the balance iron are usually supplied in the annealed or soft condition and have a tensile strength of about 70,000 psi at 68 F. Sufficient strength is retained at high operating temperatures to eliminate excessive sag or distortion of unsupported heating elements. Higher strength alloys with a tensile strength of 150,000 psi can be produced by cold working, but these materials are usually too hard and brittle for most applications. They also tend to soften above 1400 F.

As shown in the graph the change in resistance of the 35 nickel-20 chromium alloy with increasing temperature is somewhat greater than that of the other resistance alloys. At a temperature of 1700 F the resistance of this alloy is about 23% higher than the value at 68 F. For most calculations it can be assumed that the temperature coefficient of resistivity is constant from 68 to 1700 F and has a value of 0.000179 per °F.

Operating factors—This group of alloys was developed especially to meet the demand for low cost resistance materials suitable for operation at comparatively low temperatures. They are not as widely used in appliances as the 80 nickel-20 chromium and the 60 nickel-16 chromium-iron alloys. Rather, they are intended principally for controlled atmosphere furnace applications at intermediate temperatures of 1500 to 1900 F. These alloys are more highly resistant to sulfur attack than higher nickel alloys, and are resistant to preferential intergranular oxidation known as "green rot." These types of corrosion are usually encountered at intermediate temperatures and in reducing atmospheres.

Cost—The principal advantage of the 35 nickel-20 chromium-iron alloys is their low cost. Though the electrical and mechanical properties of the alloys are not as good as those of the 80 nickel-20 chromium alloy, materials cost is lower. The current price of 0.032-in. bare wire is about $2.39 per lb.

Electric furnace—*Panels containing iron-chromium-aluminum-cobalt rod elements are inserted vertically into furnace.*



4. Iron-chromium-aluminum-cobalt

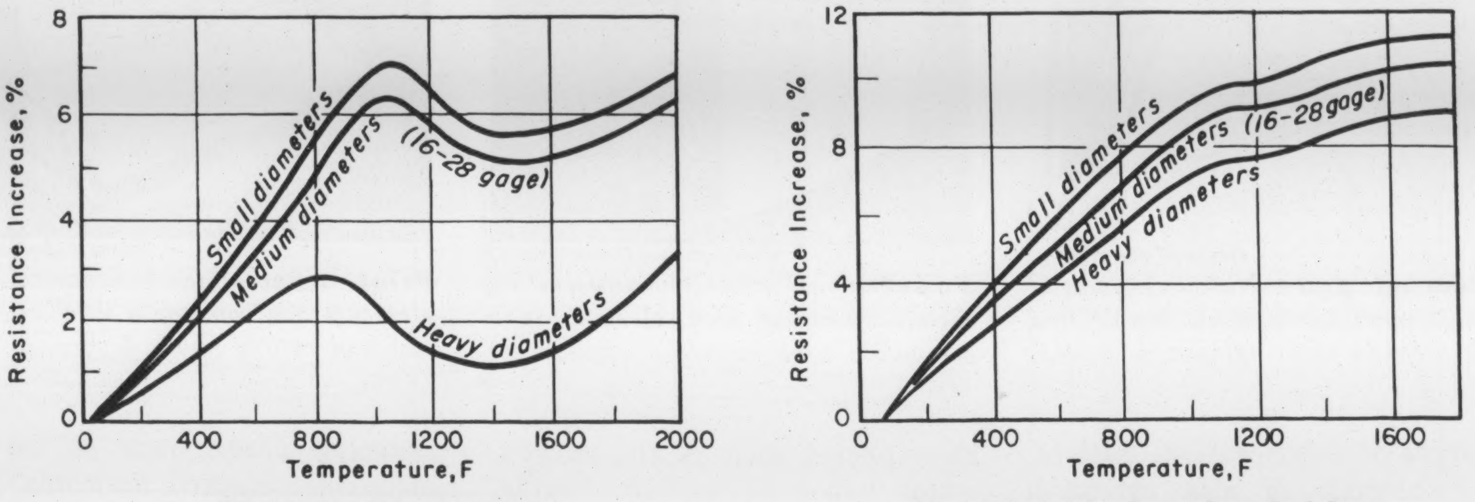
Properties—These alloys generally contain 22 to 23% chromium, 4 to 6% aluminum, 0 to 2% cobalt and the balance iron. Principal advantages of these alloys over conventional nickel-chromium and nickel - chromium - iron resistance alloys include: 1) higher operating temperatures, 2) higher resistivity, and 3) longer life at high temperatures. Because of their tendency to grow and because of their relatively low strength at high temperatures, the materials require somewhat more support than the nickel-chromium and nickel-chromium-iron alloys.

Maximum operating temperature of the materials ranges from about 2100 to 2460 F. In general, temperature limits vary with aluminum content and are highest for alloys having 6% aluminum.

Resistivity also varies with aluminum content, ranging from 812 to 872 ohms per cmf. These values are about 25 to 34% higher than for the 80 nickel-20 chromium alloy, 20 to 29% higher than for the 60 nickel-16 chromium alloys, and 35 to 45% higher than for the 35 nickel-18 chromium alloys.

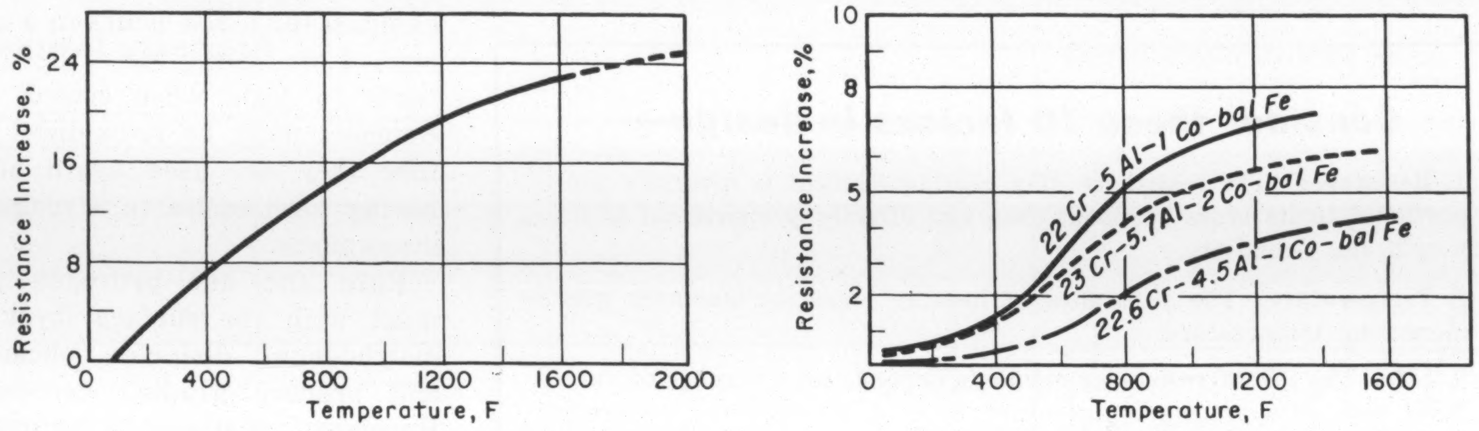
Operating factors — The iron-chromium-aluminum-cobalt alloys are used in diverse applications including cigar lighters, appli-

Resistance vs temperature



80 nickel-20 chromium

60 nickel-16 chromium-bal iron



35 nickel-20 chromium-bal iron

Iron-chromium-aluminum-cobalt

ances and electric furnaces (except in reducing atmospheres). At temperatures below 2100 F the life of the alloys is roughly the same as that of the nickel-chromium-iron alloy. However, above this temperature the life of the iron-chromium-aluminum-cobalt alloys is substantially greater than any of the nickel-chromium alloys.

Under certain conditions the iron-chromium-aluminum-cobalt alloys are subject to oxidation. Care must be taken to avoid contact with refractories containing silica and iron oxide. Also, the alloys have a tendency to become brittle after long use.

Cost — The cost of iron-chromium-aluminum-cobalt alloys varies widely, the higher temperature alloys usually being the most expensive. Cost of a typical alloy is $2.84 per lb for 0.32-in. wire.

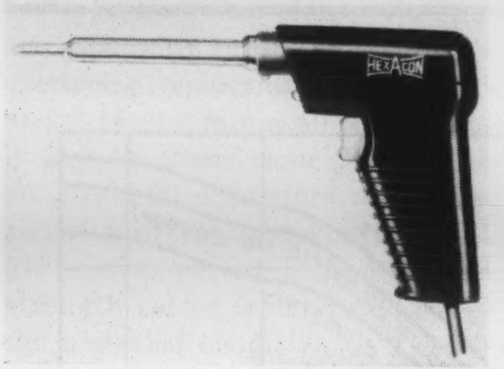
5. Molybdenum disilicide

Properties—This resistance material is comparatively new and is made up primarily of molybdenum disilicide (about 95%), plus silicon dioxide and other metallic and ceramic materials. It is produced by powder metallurgy techniques in the form of circular rods which can be formed into suitable heating elements.

At room temperature the material is hard and brittle, has a low impact strength, and has relatively high bending and tensile strengths. It should not be subjected to any substantial bending or impact stresses below 2000 F. Above 2000 F, the material is fairly ductile and can be bent or wound into the desired shapes. Used elements cannot be reformed.

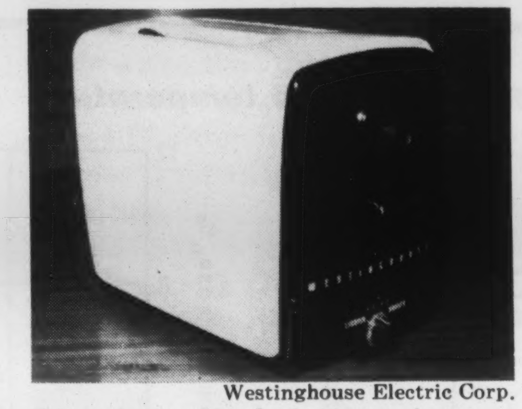
As shown in the accompanying table, the specific resistivity of molybdenum disilicide is high and increases rapidly with increasing temperature. Thus, for a constant voltage, the power consumption decreases as the temperature rises. Average resistivity of the material over a temperature range of 68 to 2900 F is 0.0027 per °F.

Operating factors—The molybdenum disilicide resistance material was developed especially for furnace heating elements designed to operate at temperatures up to 2900 F. Definite life figures cannot be established. However, it is known that operating life of the material is extended when furnaces are operated continuously. Elements have been operated for one year of continuous operation at a temperature of 2730 F with



Hexacon Electric Co.

Soldering gun—*Nickel-chromium-iron element heats ¼-in. tip of this unit seconds after trigger is pulled.*



Westinghouse Electric Corp.

Toaster—*Nickel-chromium or nickel-chromium-iron elements are commonly used in home appliances.*

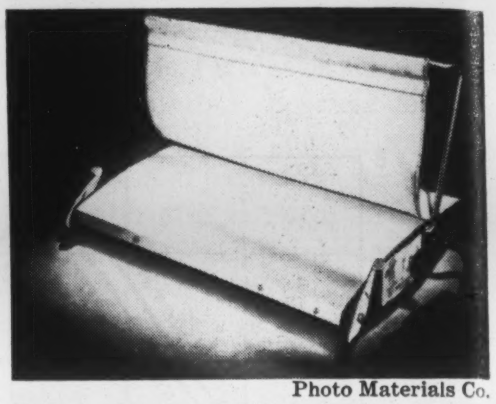


Photo Materials Co.

Print dryer—*Nickel-chromium-iron elements are commonly used in both flat and rotary photo dryers.*

no signs of deterioration. Life of the materials is also extended when they are used in oxidizing atmospheres such as air, oxygen, water vapor or carbon dioxide. Good results are also obtained in reducing gases, such as carbon monoxide, cracked ammonia and hydrocarbons, provided the heating elements have been previously oxidized for a few hours in a current of air. Since the oxide layer tends to scale when cooled, the elements must be re-oxidized before they are used again after having been cooled in a reducing atmosphere.

Consider these 10 factors in design—

1. **Resistance.** The resistance of a heating element is inversely proportional to its cross sectional area and directly proportional to its length and resistivity.
2. **Temperature.** The resistance of heating elements increases with increasing temperature.
3. **Life.** The life of resistance elements depends on a number of variables such as operating temperature, type of atmosphere, frequency of cycling, type of support, etc. Exact life values are difficult to estimate and precise values are usually determined by actual operating tests.
4. **Voltage.** Elements designed for 115 v cannot be expected to work properly when operated at 230 v. A 230-v unit should be designed from scratch. Also, it is difficult to design a good 230-v element for a small unit.
5. **Wattage.** Remember that 1% excess voltage will cause 2% excess wattage. If you want an element to draw more power you should decrease the length or increase the diameter of the wire. Consider the effect of temperature on resistance if an accurate wattage value is required.
6. **Movement.** Try to design elements so that they are free to expand or contract. Check to see if movements are liable to cause any trouble during operation.
7. **Coil ratio.** Design coils with a ratio of arbor size to wire size of less than 10 and more than 3. Coils with ratios outside these values are difficult to make.
8. **Joining.** Satisfactory joints between alloy wire and terminals are produced by welding or brazing. Pressed or pressure joints are usually all right, but should be thoroughly checked. Don't use a pressure joint with a brass terminal if temperatures are over 300 F. The zinc will oxidize and form an insulating film.
9. **Wrapping.** If wire is to be wrapped around a terminal, do so in a clockwise direction. Don't lap the wire; a raised strand is liable to be cut by the pressure of the clamping device.
10. **Mounting.** Mount heating elements so the heat flows as easily as possible into the work being heated. Try to double back end of element so as to reduce temperature at terminal.

Pure and dry hydrogen will react with the surface layer of molybdenum disilicide elements and produce gradual corrosion. However, resistance to hydrogen can be obtained by adding a small quantity of a gas containing oxygen, such as water vapor. Sulfur and its compounds, as well as metals and enamels that tend to react with silicon or silicon dioxide, should not be allowed to come in contact with these heating elements.

Cost—Molybdenum disilicide is difficult to compare in price with the alloys described above since the material is intended for special high temperature applications. Also, comparable prices cannot be given since the material is not manufactured in the smaller wire sizes. Typical cost of ¼-in. extruded rod is $10.30 per ft. The cost of ½-in. dia elements is $29.40 per ft.

Acknowledgment

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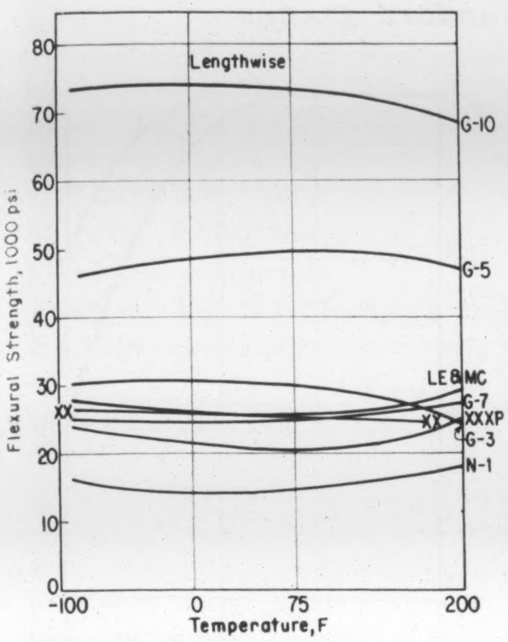
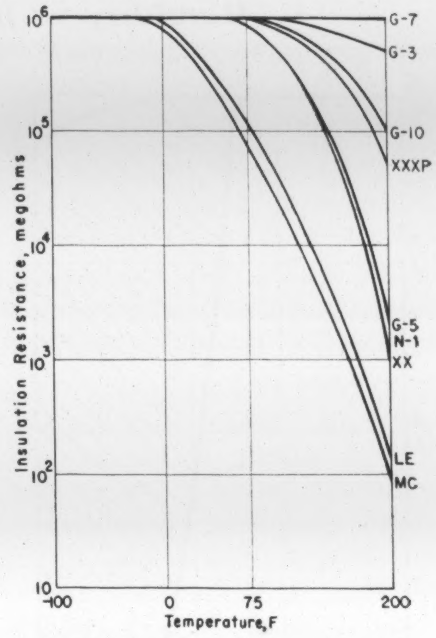
Techalloy Co., Inc.
Wilbur B. Driver Co.

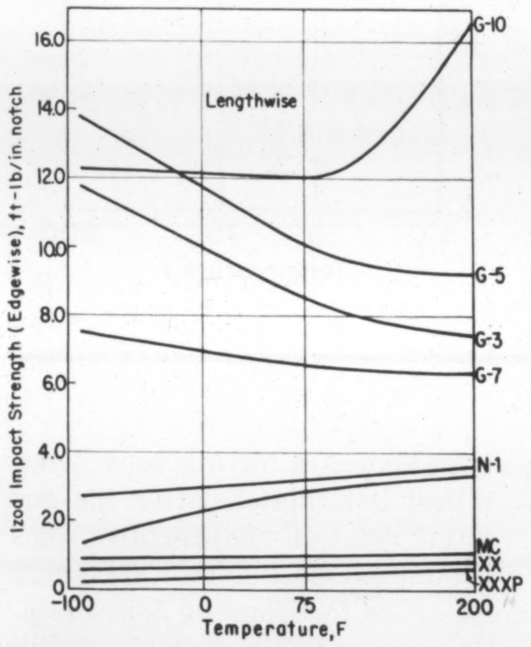
TEMPERATURE VS . . .



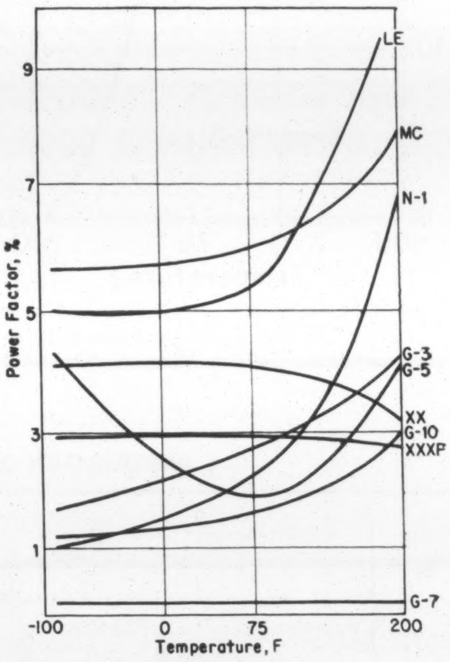
Flexural strength



Insulation resistance



Impact strength



Power factor

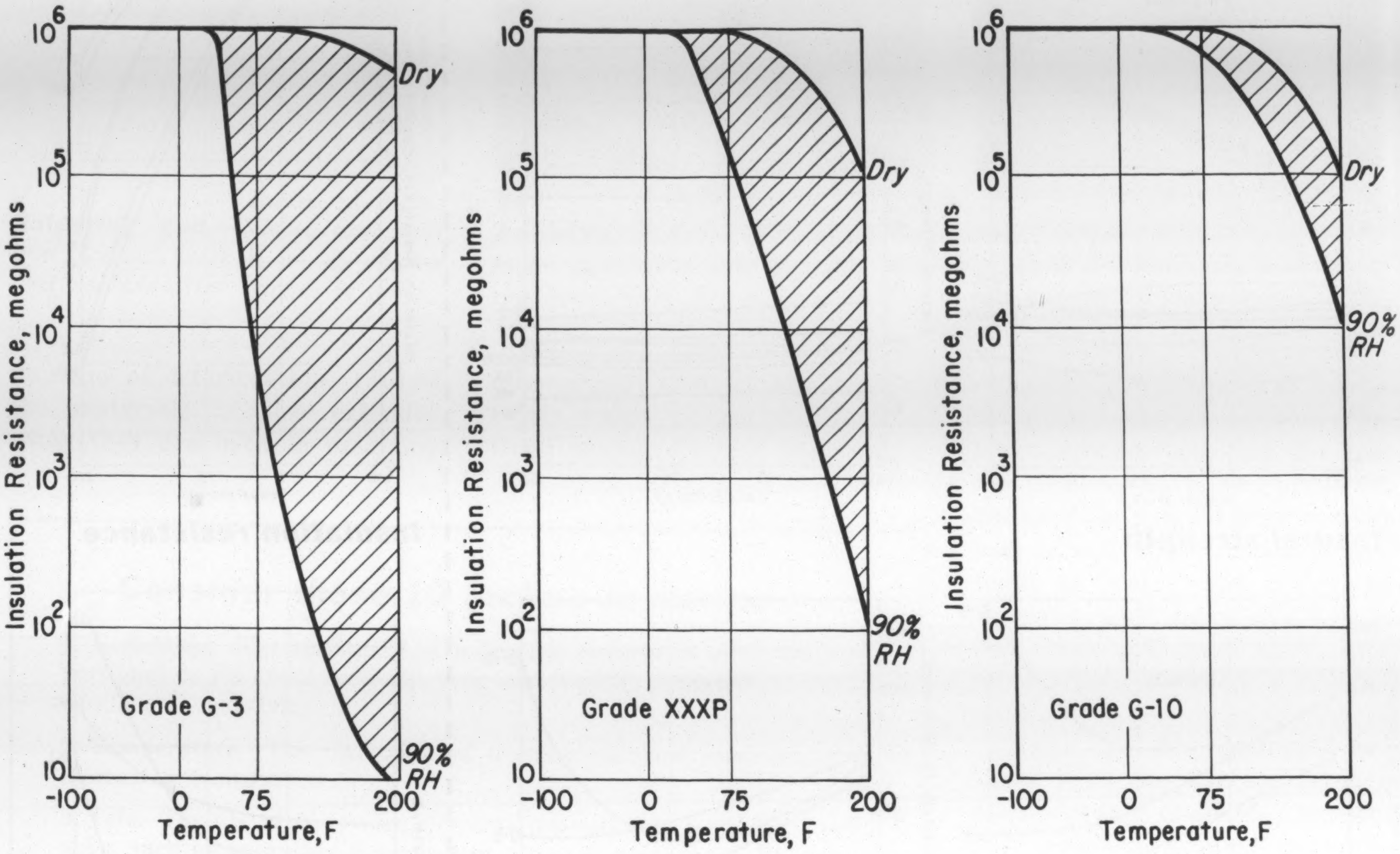
These curves show Effect of Temperature on Industrial Plastics Laminates

Few data are available on specific mechanical and electrical properties of thermosetting laminates at extremes of temperature. Here are the results of recent extensive tests on nine representative materials at temperatures ranging from –90 to 200 F.

■ The graphs give the properties of two paper-base phenolic, one nylon-base phenolic, four glass-base and two cotton-base laminates—all 1/8 in. thick. Flexural strength and impact strength were selected as representative of mechanical properties; insulation resistance and power factor as representative of electrical properties. The properties given are

by Norman A. Skow,
Director of Research, Synthane Corp.

Humidity vs insulation resistance for three standard grades



DESCRIPTION OF MATERIALS TESTED

Grade ↓	Reinforcement	Resin	Major Characteristics
XX......	Paper	Phenolic	Good mechanical properties, well suited for normal electrical use.
XXXP....	Paper	Phenolic (plasticized)	Hot punching grade with high insulation resistance and good resistance to moisture
G-3......	Glass cloth	Phenolic	Excellent mechanical strength, low power factor
G-5......	Glass cloth	Melamine	Mechanical properties similar to those of G-3 plus high resistance to heat, flame and arcing
G-7......	Glass cloth	Silicone	Excellent dissipation factor and insulation resistance under humid conditions, excellent resistance to heat and arc, good impact and flexural strength
G-10.....	Glass cloth	Epoxy	Excellent dielectric characteristics, maintained over wide range of humidities and temperatures; good dimensional stability
LE.......	Cotton fabric (fine weave)	Phenolic	Good mechanical and electrical properties and moisture resistance; highly machinable
MC......	Cotton fabric (fine weave)	Melamine	Excellent dielectric properties, resistance to flame, heat, arcing and alkalis
N-1......	Nylon fabric (staple fiber)	Phenolic	Electrical properties similar to XXXP; improved toughness, insulation resistance, moisture resistance.

instantaneous, having been determined immediately after the material reached temperature; thus the curves do not indicate aging effects (a forthcoming Johns Hopkins report will be concerned with aging effects).

Mechanical properties

Flexural and impact strengths of the laminates are better than was expected at the extremes of temperature to which they were exposed.

Flexural strength values for all nine laminates tested are relatively unaffected by temperature and are quite uniform. Impact strength values for the paper and cloth-base grades tend to remain the same or increase slightly as temperature increases. Glass-base grades show a curious and substantial improvement in impact strength at lower temperatures. For example, at –90 F impact strengths of Grades G-3 and G-5 (tested lengthwise) are considerably higher than at room temperature. Values for G-10 lengthwise increase markedly at about 100 F and continue to increase with increasing temperatures. When tested crosswise, G-10 has substantially higher values at both high and low temperatures than at room temperature.

Electrical properties

All of the laminates register dry insulation resistance values of 10^6 megohms (or, for all practical purposes, infinity) at –90 F. Grade G-7 maintains this value at all temperatures up to 200 F; five grades (G-3, G-10, G-5, N-1 and XX) maintain this value at temperatures up to about 75 F; and two nonelectrical grades (LE and MC) maintain this value to only about 30 F.

The curves on p 110 show the results of the combination of temperature and 90% RH on insulation resistance of three types of laminates and indicate how operation under moist conditions can be improved by selection of the proper grade of laminate; in this case, G-10.

With the exception of Grade G-5, power factor is relatively consistent for all laminates over the temperature range of –90 to 75 F. Grade G-7 has an extremely low and consistent value over the entire temperature range, and Grade XXXP is also remarkably consistent both at low and high temperatures. All grades show generally consistent power factors over the temperature range of –90 to 72 F.

Reference

Ito, K., "Measuring Temperature Dependence of Mechanical Properties of Plastics," *Modern Plastics*, Nov '57, p 167.

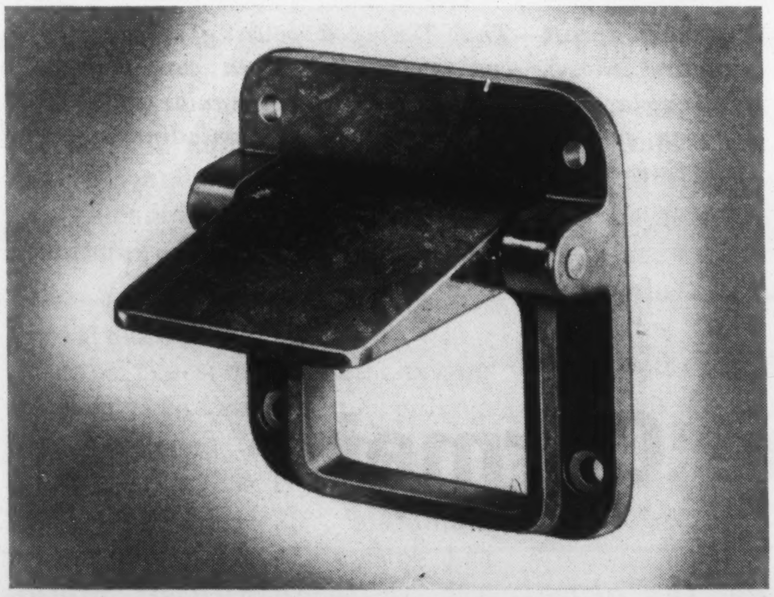
Industrial Plastics Laminates

The term "industrial plastics laminates" in this article refers to high pressure plastics laminates composed of a reinforcement and a thermosetting resin binder. The laminates are formed by heat and high pressures.

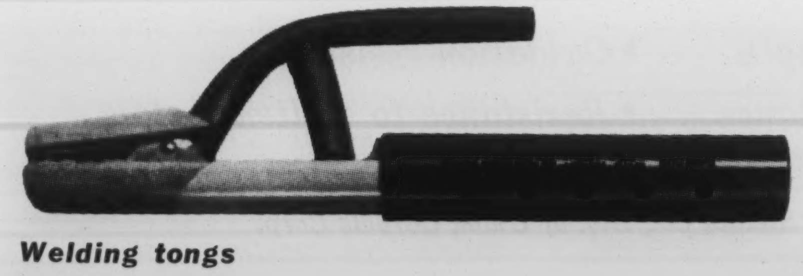
There are many types of industrial laminates, differing in reinforcement and in resin binder. However, the materials have become somewhat standardized, grade designations and property specifications having been developed by the National Electrical Manufacturers' Assn. (for information on industrial plastics laminates, see MATERIALS & METHODS, Feb. '57, p 121).

Mechanical applications for laminates include gears, pulleys, rotor vanes, ball bearing retainers, housings and a variety of other structural components. Electrical applications include components for power transformers, relays, switches, motors and other electrical or electronic apparatus. Chemical stability of the materials makes them suitable for use in plating barrels, plating air agitating structures, photography processing equipment and other applications where the part is to come in contact with chemicals or other corrosive materials.

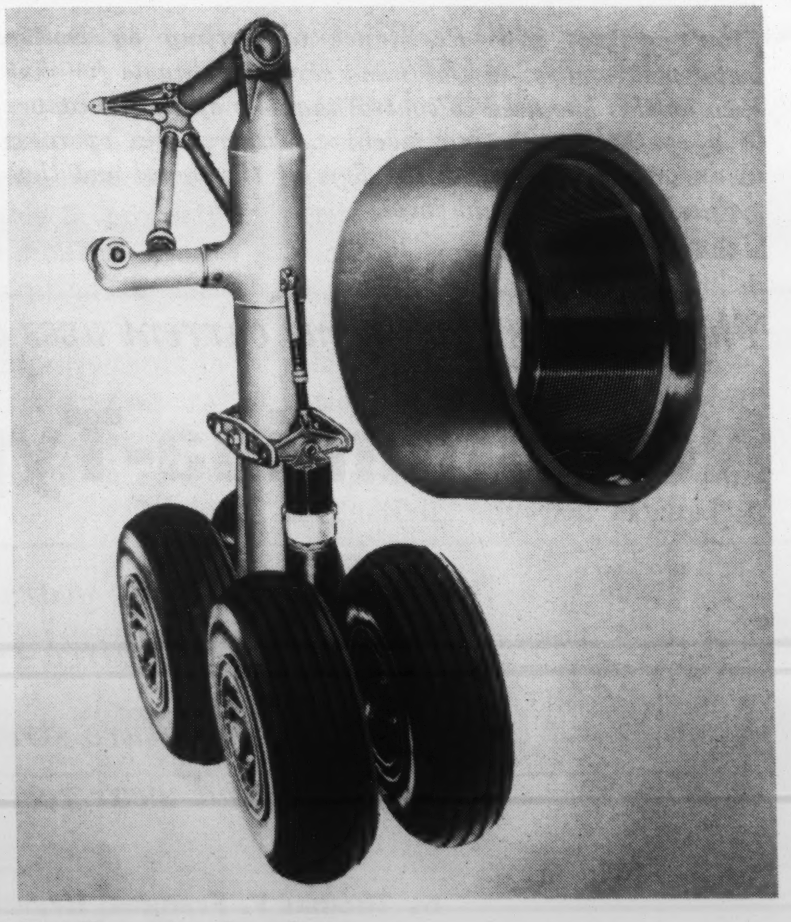
Temperatures are critical for laminates in such uses as . . .



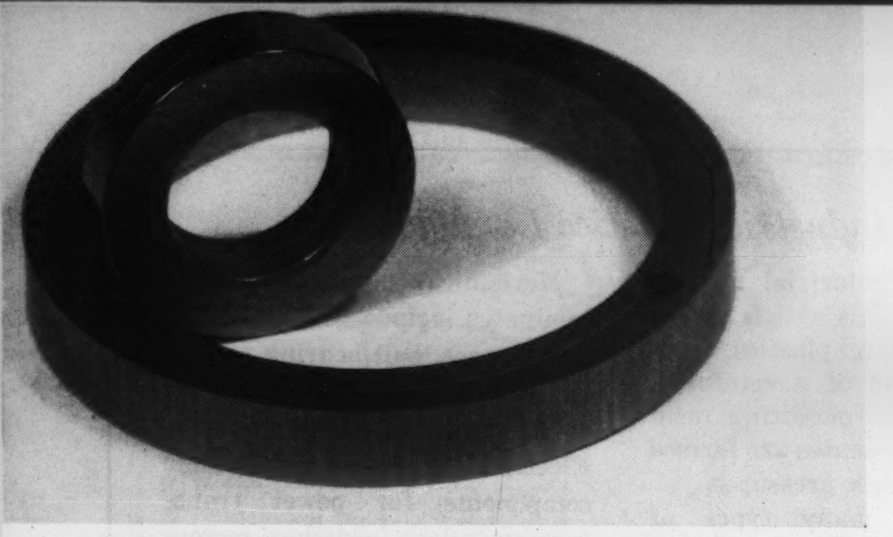
Aircraft fuel tank valves



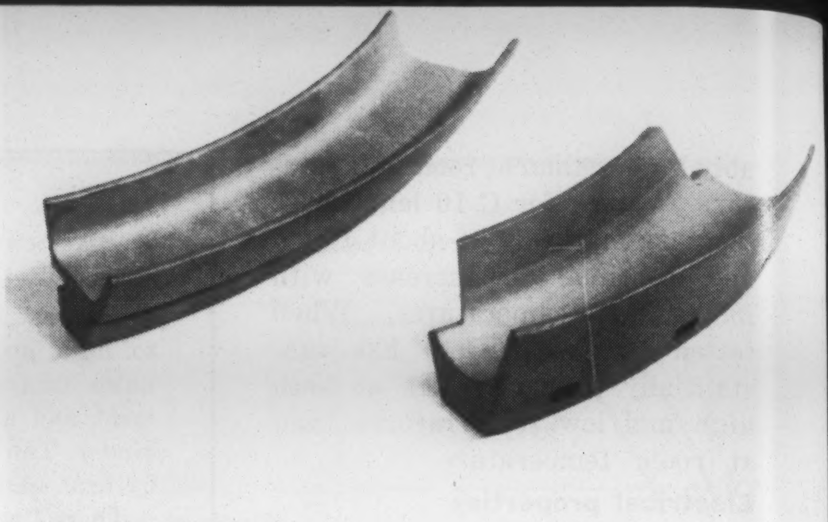
Welding tongs



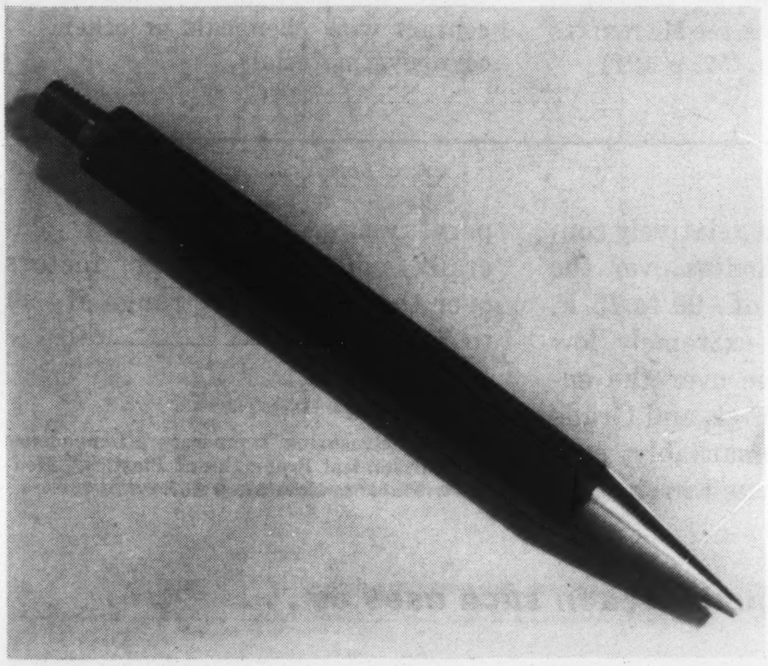
Landing gear bearings



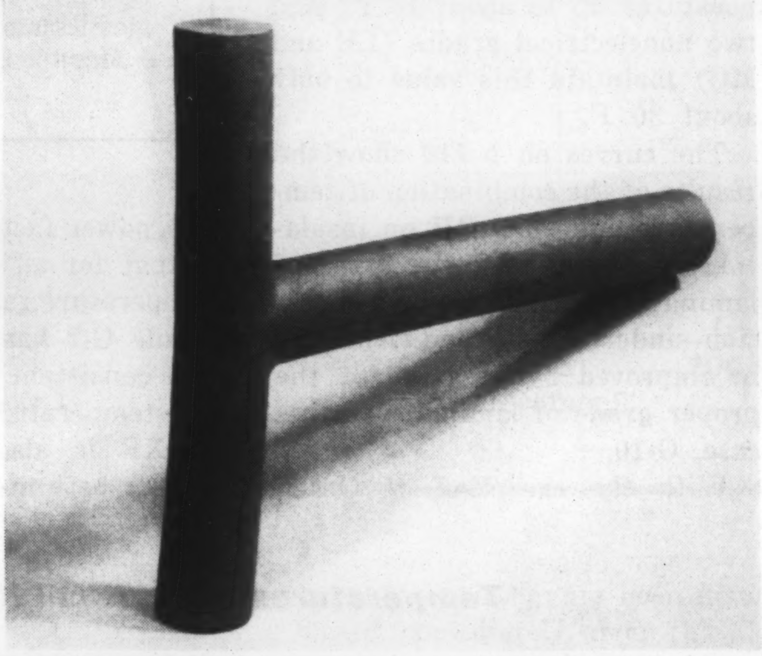
Mechanical seals — *Chromium-molybdenum-alumina compositions have particularly good wear resistance at 1200 F under nonlubricated conditions. At lower temperatures chromium-alumina seals are used in transfer pumps for high concentration sulfuric acid or oleum. Seals shown are rough machined and finish ground to size, then lapped with an alumina abrasive.*



Flame holders—*Design configurations possible with slip casting techniques are indicated by these flame holder segments made of chromium-alumina cermets. Holes were cored and formed in casting. Overhang and change in section thickness are kept to a minimum.*



Flow control pin—*Resistance to wetting by molten metal makes chromium-alumina cermets suitable for pins such as this one used to control the flow of molten copper in a continuous casting machine. Tapered pin operates in an orifice to regulate the flow of the metal and thus maintain proper liquid level.*



Pouring spout—*This T-shaped pouring spout, cast to size and shape, was designed to feed copper from a continuous casting machine to a rectangular ingot mold. It was produced to replace a ceramic-lined, welded chromium-iron pipe assembly.*

These photos show some current uses of

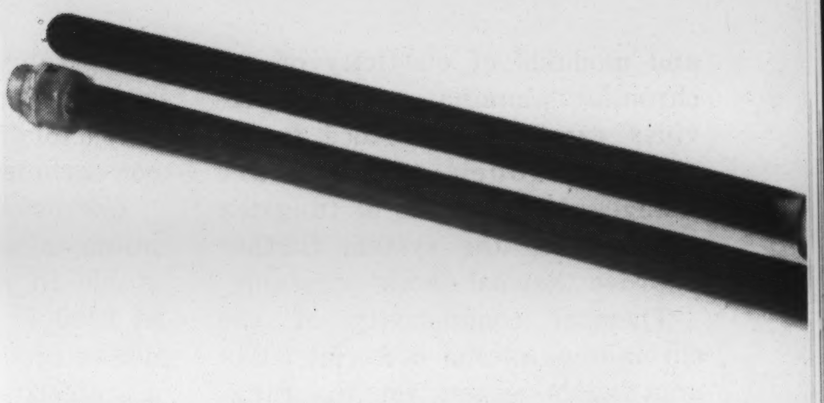
New Alumina-Type Cermets

Developed several years ago, the aluminum oxide family of metal-ceramics has acquired two new types. These materials provide . . .

- *High temperature strength*
- *Erosion and wear resistance*
- *Oxidation resistance*
- *Resistance to molten metals*

by **Thomas F. Frangos,** *Haynes Stellite Co., Div. of Union Carbide Corp.*

Rocket nozzle inserts—*Made of both the tungsten- and the molybdenum-containing cermet compositions, these rocket nozzle inserts show excellent resistance to erosion and abrasion at rocket blast temperatures of several thousand degrees. The high thermal conductivity and heat capacity of these materials make them adequate heat sinks for use in solid propellant motors where regenerative cooling is not feasible.*



Thermocouple protection tubes—*High thermal conductivity and good resistance to heat and corrosive environments make metal ceramics suitable for thermocouple protection tubes. These are used in open hearth furnace checkers, in copper and brass melting pots, and under abrasive conditions where gas-borne particles rapidly erode metal tubes.*

■ The new cermets retain useful strengths at temperatures above 2300 F, and have excellent resistance to molten metals, chemicals, oxidation, wear and high temperature erosion. Products are produced by slip casting, permitting considerable design flexibility. Finished shapes to close tolerances can be produced by machining and grinding.

Limitations of the materials are: 1) they are relatively brittle and not recommended for use under high stress or mechanical shock conditions; 2) they should not be used in carburizing atmospheres, since under these conditions they become more brittle and there is some dimensional distortion; and 3) they are not recommended for use in molten aluminum, or in acid and carbide slags.

Types available

Three types of cermets having alumina as the ceramic phase have been developed (see Table 1).

LT-1—The first type consists of 77 chromium and 23% aluminum oxide by weight. This type has been produced on a developmental basis for several years (see MATERIALS & METHODS, May '50, p 61) and has been tested in a variety of industrial applications. Properties of the material are shown in Table 2. It has excellent resistance to oxidation at temperatures up to and above 2200 F. It resists wetting by molten metals, is chemically inert to many corrosives, and has moderate strength at temperatures where many metals become molten.

LT-1b—In an effort to improve high temperature strength, molybdenum and a small percentage of titanium oxide are substituted for part of the chromium and alumina content. Properties are shown in Table 2. This composition provides a significant increase in tensile strength and stress-rupture properties, as well as thermal shock resistance. There is a slight loss in oxidation resistance.

LT-2—Tungsten is substituted for a considerable part of the chromium content in order to further improve strength and resistance to abrasion and erosion. As can be seen in Table 2, property data are extremely limited. However, the limited testing to date indicates that the material provides substantial improvements in modulus of rupture, erosion resistance and hardness at considerable sacrifice in oxidation resistance.

Properties

High temperature strength—The chromium-alumina base cermet can be used for low stress applications, such as furnace components and muffles at temperatures above 2300 F. The chromium-molybdenum-alumina material has higher strength, retaining a modulus of rupture of about 11,800 psi at 2400 F. Although insufficient data are presently available on strength retention of the tungsten - chromium - alumina material at elevated temperatures, indications are that its strength retention is superior to that of the other two compositions.

In the lower temperature ranges (up to 1500 F) some metal alloys have mechanical properties superior to those of the cermets. Nonetheless, these cermets should be given consideration in applications where their low density and relatively high strength-to-weight ratio can be used advantageously.

Thermal shock resistance—The combination of strength, thermal conductivity, thermal expansivity

TABLE 1—COMPOSITION OF CERMETS (Percent by weight)

Type ↓	Chromium	Alumina	Molybdenum	Titanium Oxide	Tungsten
Chromium-Alumina (LT-1)	77	23	—	—	—
Molybdenum-Chromium-Alumina (LT-1b)	60	18	20	2	—
Tungsten-Chromium-Alumina (LT-2)	25	15	—	—	60

and modulus of elasticity of the chromium-alumina cermet provides excellent resistance to repeated sudden temperature changes. Molybdenum or tungsten additions to the system further improve thermal shock resistance.

Thermal conductivity of the chromium-alumina material (data unavailable as yet for the tungsten or molybdenum types) is similar to that of cast iron. This high value is contributed by the continuous metal matrix, and provides particular advantages when the material is used in thermocouple protection tubes.

Erosion and abrasion resistance —All three compositions have excellent resistance to abrasive or erosive conditions at temperatures up to 2300 F. The addition of tungsten to the base material provides phenomenal resistance to the severe erosive conditions encountered in rocket nozzles. Results show less throat enlargement in a tungsten-chromium-alumina nozzle than in those made from refractory materials such as silicon carbides, borides and graphite.

Corrosion resistance — Chromium - alumina cermets remain stable in oxidative environments at 2300 F and above. Under oxidizing conditions chromium forms a protective surface layer of chromium oxide which is tightly bonded to the metal phase and protects it from further oxidation. The alumina ceramic phase is inherently stable at these temperatures.

The molybdenum-containing composition is almost as good as the chromium-alumina type in oxidation resistance. The tungsten-containing composition is substantially poorer than either and is not recommended for use in oxidizing atmospheres.

The layer of chromium oxide that provides oxidation resistance also provides resistance to attack by molten metals. Alloys containing iron, copper, brass, zinc, lead and other metals do not wet the cermets. A cermet tube survived 240 dips in molten brass; previously used materials withstood about 15 dips.

TABLE 2—TYPICAL PROPERTIES OF CERMETS

	Chromium-Alumina (LT-1)	Molybdenum-Chromium-Alumina (LT-1b)	Tungsten-Chromium-Alumina (LT-2)
PHYSICAL AND ELECTRICAL PROPERTIES			
Density, lb/cu in.	0.21	0.22	0.33
Melting Point (approx), F	3362	—	—
Poisson's Ratio	0.22	0.25-0.27	—
Electrical Resistivity, microhm-cm	87	—	—
Coef of Ther Exp, per °F	4.7[a]	5.2[b]	—
Ther Cond, Btu/hr/sq ft/°F/in.	348[c]	—	—
Specific Heat (calc), Btu/lb/°F	0.16	0.14	—
Porosity	<0.25%	<0.25%	<0.25%
MECHANICAL PROPERTIES			
Rockwell Hardness	C37	C45-55	C55
Modulus of Rupture, psi			
Room Temperature	45,000	55,000	70,000
1800 F	27,000	54,600	—
2100 F	18,000	29,000	—
2400 F	4,600	11,800	—
Modulus of Elasticity (rm temp), 10^6 psi	41	37-39	—
Compressive Strength (rm temp), psi	110,000	240,000	—
Ultimate Tensile Strength, psi			
Room Temperature	21,000	—	—
800 F	20,500	—	—
1200 F	20,000	—	—
1500 F	19,700	—	—
1800 F	16,800	—	—
2000 F	11,700	—	—
Modulus of Rigidity (rm temp), 10^6 psi	17	15	—
Shear Strength (rm temp), psi	40,000	—	—
Bulk Modulus, 10^6 psi	21	26	—

[a] At 32-1832 F. [b] At 68-1472 F. [c] At 500 F.

Chemicals such as sulfur dioxide, sulfur trioxide and concentrated sulfuric and hydrochloric acids attack these cermets very slowly. Tested in a chemical mixture containing vanadium pentoxide (intended to simulate the ash residue found in crude oil boilers), all materials showed excellent resistance, the molybdenum-chromium-alumina type performing best. Thermocouple protection tubes made of chromium-alumina cermets have been in use for over three years at 2200 F in a sulfur burning furnace.

Design considerations

The slip casting technique permits production of a large variety of shapes and sizes of parts that cannot be formed practically by pressing or extrusion. The design flexibility of such shapes is indicated by the photographs on pp 112 and 113.

Several design recommendations will aid in specifying parts produced of these materials by the slip casting process:

1. *Size* — Length of parts is limited mainly by the length of furnace equipment which, at present, is about 42 in. Cross section of the piece is also a factor in determining length. For example, tubes from ¾ to 3½ in. in dia can be produced in 42-in. lengths, whereas the length of rods of ¼-in. dia might be limited to 15 in.

Tubular lengths longer than 42 in. can be produced by threading and joining segments. Where service temperatures permit, brazing can be used to join parts to other cermet parts, or to steel or other metals. Differences between the coefficient of expansion of the cermet and that of the mating materials must be allowed for. Also, any layer of chromium oxide on the surface must be removed before brazing.

Maximum width of parts is dependent on other dimensions.

Pieces 11 in. square have been made on a production basis.

Wall thickness of hollow ware is limited to about ¼ in. Solid tiles up to ¾ in. in thickness have been produced. Solid blocks 3½ in. wide by 5 in. long have been produced in thicknesses up to 1½ in.

2. *Sections and edges*—Sections as thin as 1/16 in. have been successfully slip cast. When possible, edges to be finished should be chamfered to avoid breakout. Changes in section thickness should be kept as gradual as possible with pronounced radii.

3. *Radii and fillets*—Radii and fillets should be specified as large as possible, preferably no smaller than 1/16 in.

4. *Tolerances* — Tolerances on most slip cast shapes can presently be held to ±1%. Tolerances closer than ±0.001 in. can be held by machining or grinding.

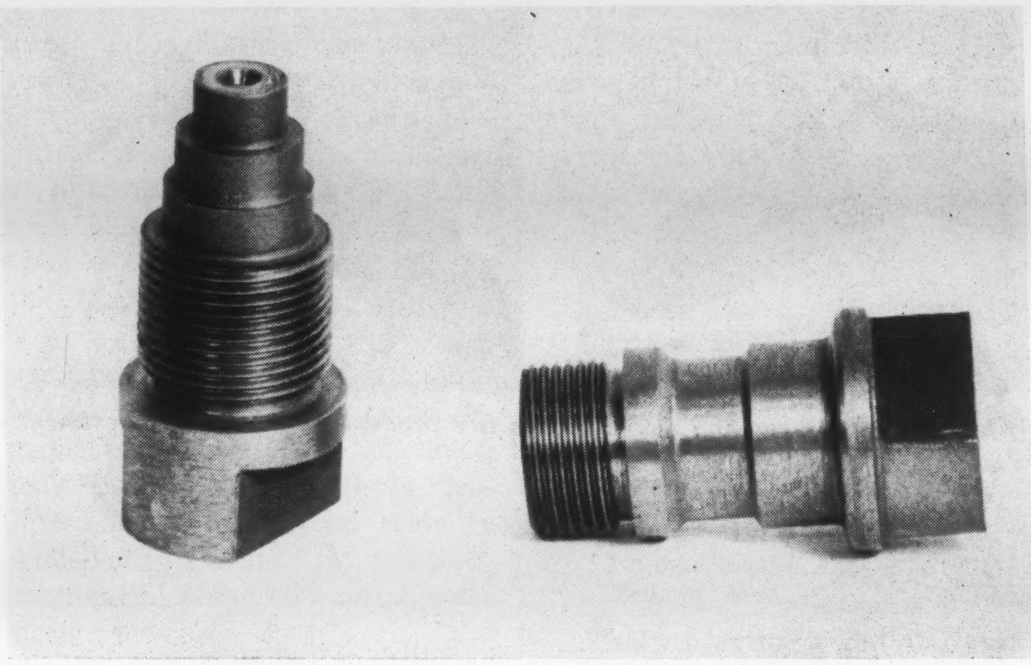
5. *Holes*—Holes can be cored or drilled as required. Cores for holes can be integral in the mold, or can consist of separate inserts.

6. *General configuration*—In designing the part, the designer or engineer should remember that the ware must be supported during the sintering cycle. Where possible, a flat surface on which the piece can rest should be designed into the part. Rounds and V-shaped cross sections can be cradled in saggers, and in some cases preformed saggers can be used to support irregular shapes.

Machining and finishing

Cermets can be machined and ground to provide close tolerances or finished surfaces. The chromium-alumina grade is readily machinable with the tungsten carbide-tipped tools used on cobalt-base alloys. The tungsten and molybdenum types, because of their greater hardness and strength, require the hardest grades of tools.

Grinding can be used to obtain a smooth surface but is not practical for heavy stock removal, since wear of the abrasive tool can be excessive. Excess stock should be rough machined from a piece prior to fine cuts or finish grinding. Experience indicates that tools must be kept sharp, small feeds (0.010 in.) and shallow cuts (0.025-0.50 in.) are preferable, and low speeds (10 to 20 sfm) are necessary. Cuts should be taken inwardly from the edge of the work to avoid chipping or corner breakdown.



Design possibilities *are illustrated by these two parts. Note 1) shapes obtainable by slip casting, and 2) the inherent machinability of the material.*

Background of the New Cermets

In the past few years the demand for materials serviceable at temperatures above 2000 F has stimulated the development of materials containing both metal and ceramic phases. These materials have been developed to provide properties that neither metals nor ceramics by themselves could provide, i.e., the ability not only to retain useful mechanical strength characteristics at these high temperatures, but also to withstand thermal shock, oxidation, abrasion, erosion and attack by severely corrosive materials.

Such composite materials are made from finely divided powders of metals and ceramics which are intimately mixed, formed and sintered. The properties of any one of these combination materials are determined by the characteristics of the metals and ceramics used, the way in which the components are dispersed, and the nature of the bond between them.

The most successful early cermets had a titanium carbide or boride base. Such materials are strong in the 1600 to 2000 F range. They are prepared by the usual powder metallurgy techniques of hot or cold pressing and sintering. Although final shaping and machining of parts produced from these materials can take place prior to sintering, thus permitting relatively complex shapes, both size and shape of parts are limited to some degree by the restrictions of the pressing process.

In the last few years a new family of cermets has been developed employing an aluminum oxide base. These materials, described in this article, are oxidation resistant, have useful strengths at temperatures over 2200 F, and have excellent resistance to wear caused by friction, abrasion and erosion occurring over a wide temperature range. They are produced by slip casting, permitting great flexibility of design in both size and shape and allowing the incorporation of undercuts and intricate internal or external contours.

***Turbine blades** of varying configuration are produced by vacuum investment casting.*

Vacuum Cast Nickel Alloy *vs* 'Best' Cobalt Alloy

As table indicates, the nickel alloy, investment cast in vacuum, is superior to the arc cast cobalt alloy for high temperature use.

by J. J. Eisenhauer and John Preston,
Microcast Div., Austenal, Inc.

COMPARISON OF UDIMET 500 AND COBALT ALLOY AMS 5382

	Udimet 500[a] (Vacuum cast)	AMS 5382[b] (arc cast)
COMPOSITION (nominal), %	Cr 18, Co 18, Mo 4, Al 3, Ti 3, C 0.10 max, Fe 2.00 max, Si 0.3 max, Mn 0.2 max, B 0.008, Ni bal	Cr 25.5, Ni 10.5, W 7.5, C 0.5, Fe 2.00 max, Co bal
PROPERTIES		
Tensile Properties (1200 F)		
Tensile Strength, 1000 psi	110[c]	34
Reduction of Area, %	8[c]	36
Stress Rupture Properties (1700 F, 25,000 psi)		
Life, hr	35[c]	1
Reduction of Area, %	6	—
Temperature for Min Life of 35 Hr at 25,000 Psi, F	1700	1525

[a] Solution heat treated 4 hr at 2100 F, air cooled; solution heat treated 4 hr at 1975 F, air cooled; aged 16 hr at 1400 F.

[b] As cast.

[c] Probable minimum values for specification purposes.

■ At 1200 F, the vacuum cast nickel-base alloy, Udimet 500, has three times the tensile strength of AMS 5382, generally considered the best available cobalt-base high temperature alloy. Still more significant: under the same conditions of stress and service life, the operating temperature can be raised from 1525 F to 1700 F by substituting the nickel alloy, now commercially available, for the cobalt alloy.

Why vacuum cast?

The improvement in properties is the result of a new process—vacuum investment casting. This process makes it possible to:

1. Use alloys generally considered not castable by conventional air melting techniques. Melting in a vacuum minimizes loss of readily oxidizable elements such as aluminum and titanium, and gives closer control of composition than air melting.

2. Use alloys containing appreciable amounts of aluminum and titanium. Effectiveness of these elements as hardeners depends not only on maintaining the required composition but also on controlling the form in which these elements precipitate as compounds in the alloy.

3. Achieve reproducible mechanical properties. Elimination of air and water vapor in vacuum melting reduces oxidation losses, variation in chemical composition, and porosity resulting from contained gases.

4. Achieve a combination of good ductility and strength at

high temperatures. Minimizing porosity, microshrinkage and inclusions in the casting increases strength without loss of ductility.

The vacuum investment casting process is suitable for producing the same type of parts characteristic of conventional arc casting techniques. Weight and size of the invested molds are the primary limiting factors in casting by either method. Other considerations governing the size of a casting produced in vacuum are the capacity of the vacuum chamber and crucible. Parts have been produced in vacuum using a centrifugal casting technique, a major advantage being that thin edged castings can be produced. Castings weighing 50 lb have been cast in vacuum, and furnace installations having a capacity of 200 lb are currently being considered for vacuum investment castings.

Materials and uses

Uses of vacuum investment castings have so far been limited primarily to turbine blades and structural members for the aircraft industry. The nuclear energy program is considering the advantages of using vacuum cast races and cages for bearings operating at high temperatures or in corrosive environments. Also vacuum cast magnets exhibiting high permeability are being considered for various applications in the electronics industry.

Alloys that can be improved by vacuum casting are GMR 235, Waspalloy, Inconel 713 and Udimet (Unitemp) 500. Of these, only Udimet 500 has been produced on a commercial scale in sufficient quantity to establish mechanical properties suitable for design purposes.

Properties of Udimet 500

Udimet 500 contains aluminum and titanium, both of which have a strong affinity for interstitial elements such as oxygen. Melting in a vacuum tends to minimize oxidation, since air and water vapor are eliminated, and a closer control of the chemical composition is achieved. The result is uniformity of properties.

This uniformity is shown by the results of a series of tests at elevated temperatures on six vacuum cast production heats of Udimet 500 (the materials had received a double solution heat treatment followed by aging, as described in note "a" accompanying the table on p 116).

The range in tensile properties at 1200 F was:

Ten Str, psi	125,000-149,000
Elongation, %	8.0-10
Red. of Area, %	8.5-12

Stress rupture properties determined at 1700 F and 25,000 psi were:

Rupture Life, hr	51-95
Elongation, %	10-17
Red. of Area, %	10-22

The properties given above are typical and are not suggested for design purposes. Probable design values for tensile and stress rupture properties are given in the table at the beginning of the article.

The comparison between vacuum cast Udimet 500 and arc cast AMS 5382 is valid because vacuum casting does not significantly improve the properties of AMS 5382. Its strength is derived primarily from the precipitation of carbides which do not oxidize and form harmful inclusions in the alloy.

Casting in a Vacuum

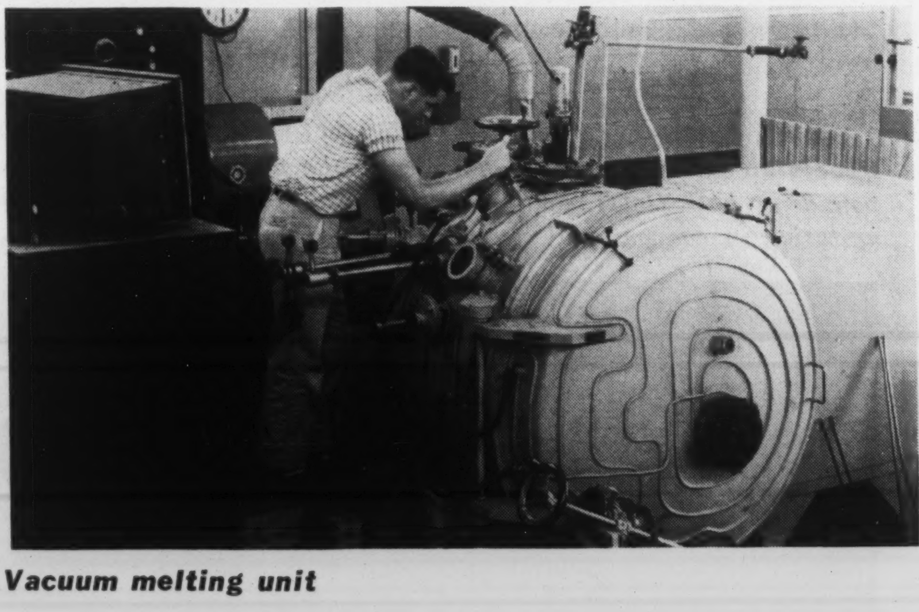
A typical vacuum casting installation consists of an induction coil within a tank connected to pumps that permit a vacuum of less than 10 mn to be achieved.

A typical installation is shown below.

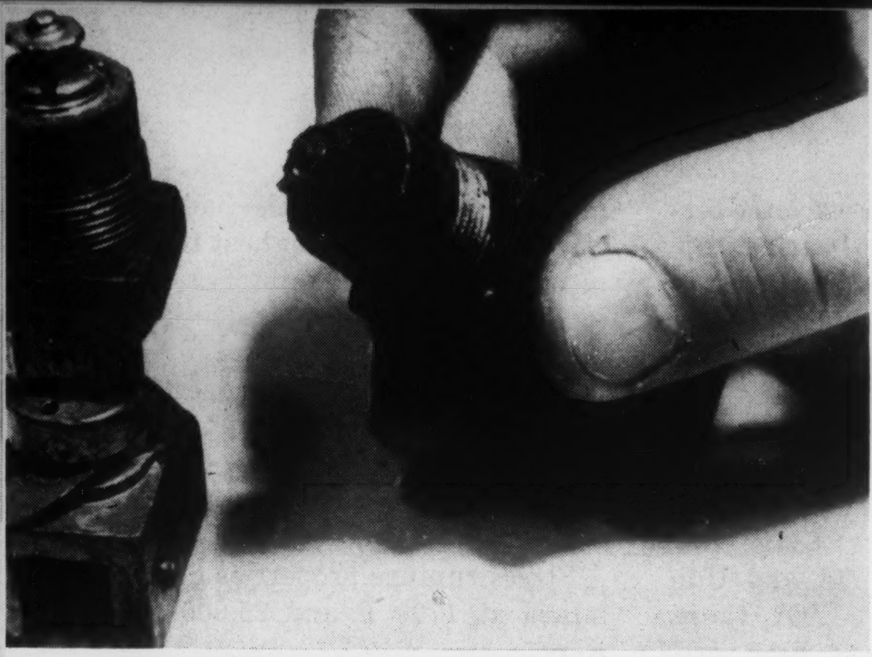
The general casting procedure is to place the metal charge and an invested mold in the tank, seal the chamber, evacuate to the desired vacuum, and melt the charge. A pressure of less than 10 mu is maintained during the melting and casting period.

A vacuum melted master heat of alloy is used for the charge, thus reducing the time required to reach the desired degree of vacuum and insuring better control of casting quality. A charge that has been previously melted in vacuum instead of air also provides better control of chemical composition from mold to mold.

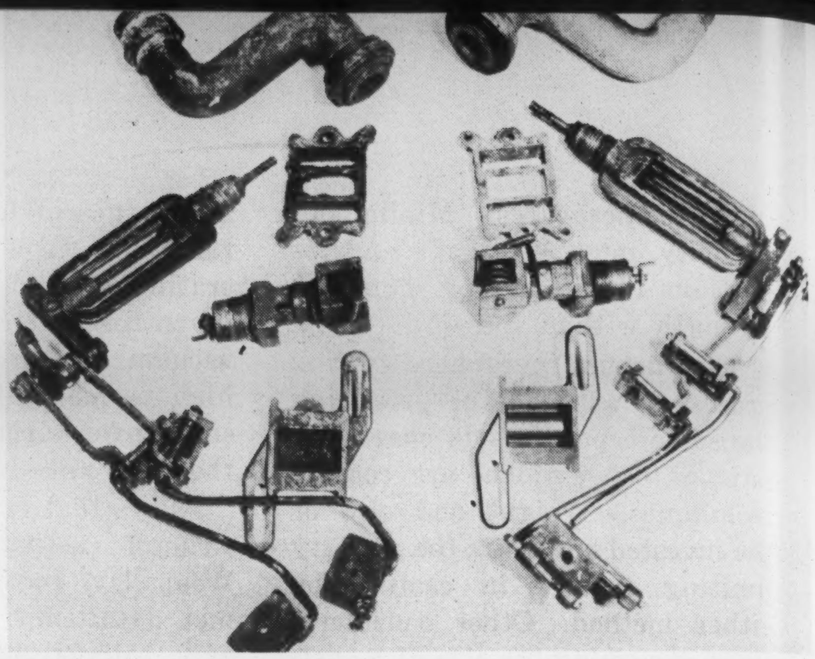
In vacuum casting the mold cavity is filled statically, not by air pressure as is characteristic of conventional arc casting. The castings are cooled in the vacuum chamber to prevent surface oxidation.



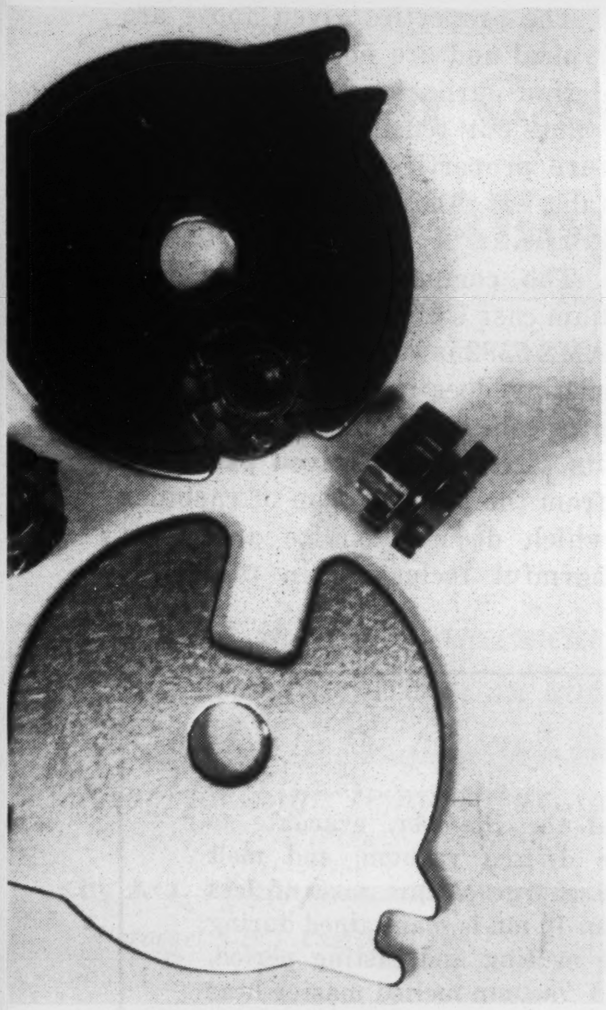
Vacuum melting unit



Gas meter *part at right is frozen by deposits. After 2 min of ultrasonic cleaning (left), it is ready for use.*



Assorted meter parts *before and after ultrasonic cleaning.*



Odometer pinion *containing deep annular groove is freed of all contaminants.*

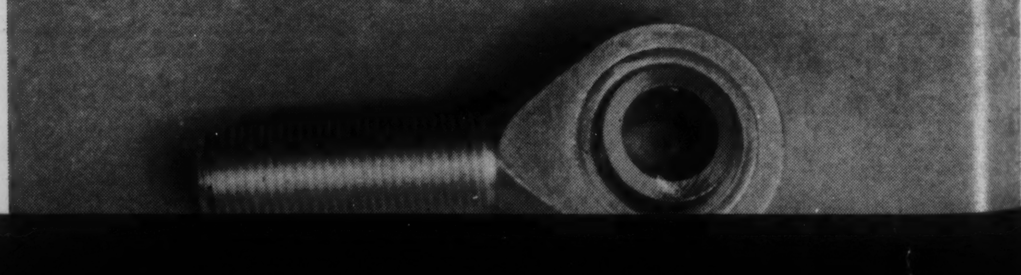
Get Parts Cleaner

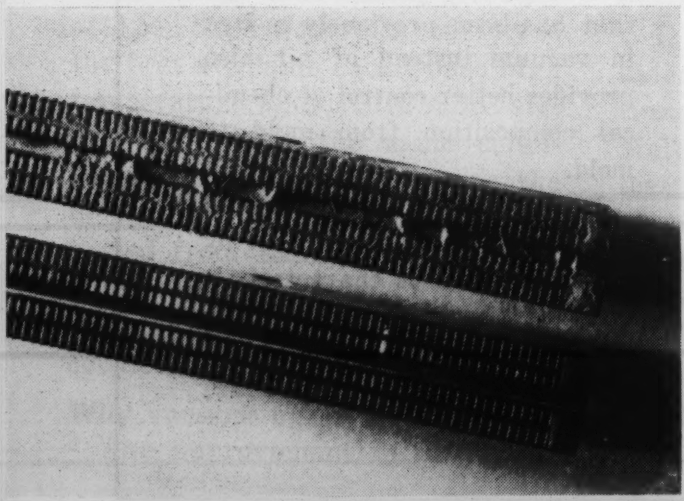
A comprehensive discussion of the advantages, limitations and technical features of an increasingly important cleaning method—used for both metals and nonmetallics.

by Norman G. Branson, *Branson Ultrasonics*

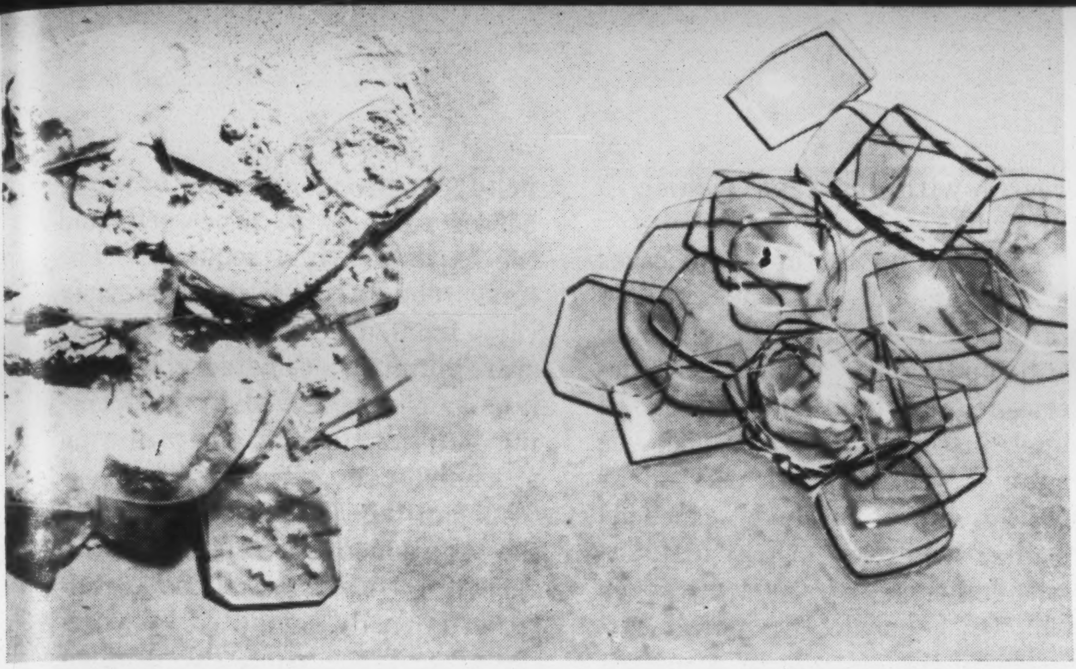
■ Ultrasonic cleaning is noted principally for its rigorous and thorough cleaning action, its speed, and its ability to clean hard-to-reach areas. Because of these advantages, the process has gained wide acceptance as a cleaning method. This article describes how the process works, the important processing variables, and specific advantages and limitations of the method.

Precision balls *and swivel are cleaned by ultrasonics. Lapping compound in ball (left) could not be removed after 10 min of hand agitation in conventional cleaning solution.*





Electric shaver head *before and after cleaning. Thorough cleaning is required for subsequent plating operations.*



Lenses *covered with rouge, grit and emery are cleaned quickly and thoroughly by ultrasonics.*

by Ultrasonics

How it works

Ultrasonic cleaning is essentially a cavitation action which is produced by mechanical vibrations in a cleaning liquid. Although cavitation induced by ultrasonic vibrations is a rather complex phenomenon and is not yet fully understood, for most purposes it may be considered as the alternate generation and violent collapse of bubbles in a liquid. This action produces an erosive or scrubbing effect on the surface of a solid.

Although any frequency beyond 18,000 cps is classified as ultrasonic, the generally accepted range of frequencies useful for cleaning extends from 18,000 to 1,000,000 cps. Actually, cleaning action can be produced at any frequency if the acoustic intensity (measured in watts per sq in.) is high enough to produce cavitation in the cleaning liquid. Cavitation can be produced at the audible frequencies, but these frequencies are not usually used because of the objectionable noise that is generated.

How vibrations are generated

Two basic elements are required to produce high frequency vibrations in a liquid: 1) a generator, to convert 60-cycle power into high frequency electrical waves, and 2) a transducer, to change the electrical waves into mechanical vibrations of the same frequency.

Frequency converters—Electricity can be converted from a frequency of 60 cycles to ultrasonic frequencies by using an electrical alternator or an electronic frequency converter. An electrical alternator is similar to a conventional alternator except for its large number of poles, added complexity and higher speed of operation. An electronic frequency converter is made up of tubes, a few controls and perhaps a cooling fan. Its principal advantage is that it does not have any moving parts and does not produce any noise.

Transducers—Electrical waves can be converted into ultrasonic mechanical frequencies by using transducers made up of piezoelectric quartz or ceramic materials, or magnetostrictive metal laminations.

If a voltage is impressed on a piezoelectric crystal, the crystal exhibits a slight increase in size, and if the voltage is reversed the crystal shrinks. Thus, when an alternating current is impressed on the crystal it alternately expands and contracts, thereby setting up mechanical vibrations.

Quartz crystals are rarely used in ultrasonic transducers, since they require very high voltages, particularly at the lower ultrasonic frequencies, and are too expensive for anything but the smaller installations. Most piezoelectric transducers are made of barium titanate ceramic. This material is formed into a usable shape by pressing and heat treating much like a sintered metal. The ceramic is silvered on two faces and is polarized by impressing a high d.c. voltage across the faces. After this treatment the ceramic exhibits piezoelectric properties.

A magnetostrictive effect is produced by placing a nickel rod or laminations in a solenoid which carries alternating current. When magnetized, the nickel rod changes in length and thereby generates mechanical vibrations. Properly designed magnetostrictive vibrators are rugged, will withstand

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About This Article

Four years ago this magazine published a popular and useful 16-page guide called "Selecting Metal Cleaning Methods" (Nov '53, p 119). At that time only a few ultrasonic cleaning installations were in operation. Today a considerable number of such installations are in use and the process has become widely accepted. There has been some confusion, however, because of the great variations among the processes developed by different companies—e.g., the widely varying frequencies, the different types of transducers and the different cleaning liquids. In this article the author eliminates the confusion, giving a clear picture of the advantages and limitations of ultrasonic cleaning you should be aware of.

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relatively high temperatures, and provide high amplitudes of vibration. In addition to ultrasonic cleaning they are particularly suited for applications in ultrasonic soldering, welding and drilling, where high amplitudes are applied to relatively small areas and to solid materials.

Which frequency?

The power required to produce cavitation varies considerably with different liquids, the amount of gas present in the liquids, and with other factors. For a given set of conditions, the power required to produce cavitation rises rapidly when the frequency exceeds 50,000 cps, and for this reason operating frequencies are usually kept below this level. Also, since any frequency below 18,000 cps is audible and can be irritating, the lower frequency limit has been set at about 20,000 cps. Magnetostrictive transducers generally operate close to this frequency because their internal losses tend to rise rapidly as frequency increases.

Due to the above factors, most equipment is operated in the frequency range of 20,000 to 50,000 cps. The choice of frequency in this range is largely a matter of personal preference and experience. Using the same type of generator and transducer, there will be little difference in either the power input or cleaning efficiency as long as the frequency is somewhere between 20,000 and 50,000 cps.

Power requirements

The amount of power that can be transmitted effectively into the cleaning liquid is limited. When the surface cavitation at the transducer radiating face becomes too intense the cleaning efficiency throughout the liquid will drop off.

In general, an increase in cleaning tank dimensions is accompanied by a drop in cleaning efficiency. The reason is that the power that can be supplied to the transducer varies in proportion to the *area* of the radiating surface, a second degree function; whereas the amount of cleaning fluid increases with the tank *volume*, a third degree function.

The guiding factor in all cases is the amount of energy (r-f watts) per gallon of cleaning fluid, and this is usually best determined by trial and error. In some installations an r-f power input of 4 or 5 watts per gal of solution may produce excellent results, whereas other installations may require 100 watts per gal. In general, the power required to the transducer averages 25 to 50 r-f watts per gal. Higher power may be required if the transducers are inefficient or if they do not provide enough effective radiating surface for the energy that must be transmitted into the cleaning medium.

Determining equipment size

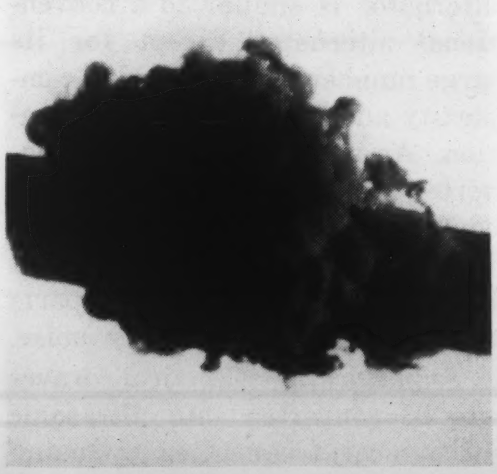
Unlined metal tanks generally work best for ultrasonic cleaning. Wooden tanks or rubber or plastics linings have a tendency to absorb ultrasonic energy and reduce the cleaning action. The system should be designed to bring the work as close to the radiating surface of the transducer as possible, and the volume of the tank should be no greater than necessary to accommodate the work.

The size of the ultrasonic transducer or bank of transducers depends on the work size, the number of parts to be processed, and the exposure time required. The time required for cleaning may vary from a few seconds to several minutes. Considerable savings can be achieved by first trying out the cleaning operation on a small scale. Results of these tests can then be used to estimate the equipment needed for full operation. The size of the installation is easily computed knowing the size of the part, the production rate, and the exposure time required to clean a part effectively. For example, to handle steel strip 1½ ft wide and moving 2 ft per sec, 3 sq ft (1½ x 2) of transducer area will be needed for each second of exposure. If it takes 4 sec to clean the steel thoroughly, then 12 sq ft of transducer area will be required to do the job.

Batch cleaning

Because of the nature of the cleaning process, careful attention must be given to the type of equipment used in batch cleaning operations. Since a screen or mesh between the part and the transducer interferes with the ultrasonic energy, the mesh should be as large as possible for the part being cleaned, a mesh 1 in. or larger being preferred. Assuming

The process in action



Erosive cleaning action *is produced by alternately generating and collapsing minute bubbles in cleaning liquid.*

Normally inaccessible dirt *is easily removed, as demonstrated here by the release of graphite particles sealed between two glass plates.*

that the transducers are mounted below the basket, the energy transmitted to the parts decreases as the mesh of the basket becomes smaller. However, at the point where a solid sheet is reached, the energy transmitted to the parts increases sharply. Excellent cleaning has been obtained using a basket with a solid stainless steel bottom 0.02 to 0.04 in. thick, and with perforated sides to provide drainage.

Some care is required when placing parts in a cleaning basket. Since ultrasonic energy is reflected at every interface, the intensity at the center of a very large mass may be too low for efficient cleaning. It is generally best to limit the depth of piled up parts to three to six times the smallest dimension of a single part, and to keep the total depth below 2 or 3 in.

Ideally, only one layer of parts should move past the radiating surface of the transducer. For this reason most satisfactory results are obtained when the parts are racked as in electroplating. Cleaning speed and efficiency can be improved somewhat if the parts are agitated gently to wash off the contaminants that have been loosened by cavitation. Complex parts with blind holes or deep crevices should be rotated in the ultrasonic bath to insure that the liquid will contact all surfaces. There will be no cleaning in a blind hole if air is entrapped in it.

Selecting the cleaning liquid

In many applications the cleaning agents previously used in conventional cleaning processes will work very well, although in other applications more effective detergents or cleaners can be substituted. Water with a wetting agent is often perfectly adequate to remove loose dust, dirt particles or machining chips. For more effective action in removing insoluble soils, oils or greases, a solvent such as trichloroethylene or soapy water should be used. An acid cleaner is usually required to remove scale produced by heat treatment or forging.

Many commercial compounds are available for ultrasonic cleaning, and the materials supplier should be consulted if there is any question. In some applications the ultrasonic equipment will have to be tested with a variety of detergents or solvents until the right one is found. In all cases it should be remembered that high viscosity liquids should be avoided, since ultrasonic cleaning is not very effective in these media.

Plus and Minus of Ultrasonic Cleaning

Advantages	**Limitations**
• Rigorous, thorough cleaning action	• Spongy deposits difficult to remove
• Cleans hard-to-reach areas	• Excess of gases in cleaning liquid limits effectiveness
• Fast operation	• Not effective in high viscosity liquids

Multiple stage cleaning

The simplest type of apparatus for ultrasonic cleaning consists of an ultrasonic generator, a transducer, a cleaning liquid and a tank. This system is perfectly adequate for small batch operations where the solution is not liable to become contaminated. In larger scale operations, however, there is danger of contamination, and a clean spray rinse should be employed after cleaning. Use of a second stage of ultrasonic cleaning with an intermediate spray rinse may also be justified.

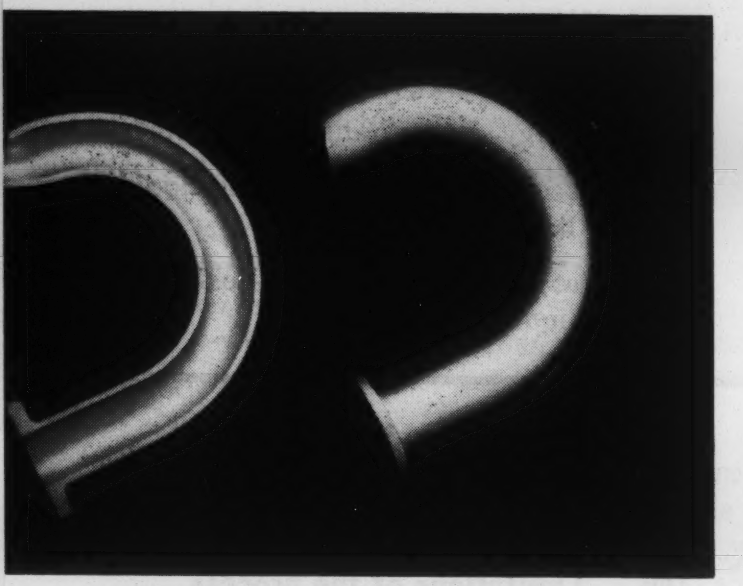
For extremely critical cleaning operations it is possible to design a system that is practically equivalent to an infinite number of cleaning stages. This system consists of a relatively long and narrow cleaning tank with transducers mounted along its entire length. The work is carried in one direction and a continuous supply of cleaning liquid flows in the opposite direction. Thus, the major portion of the soil is removed when the parts first enter the tank and in a solution that is just about to leave the tank. Final cleaning takes place at the opposite end of the tank in a perfectly clean liquid that has just entered the tank. Suitable filtering and distillation systems are employed to insure that the liquid is clean before it is recirculated.

Limitations of the process

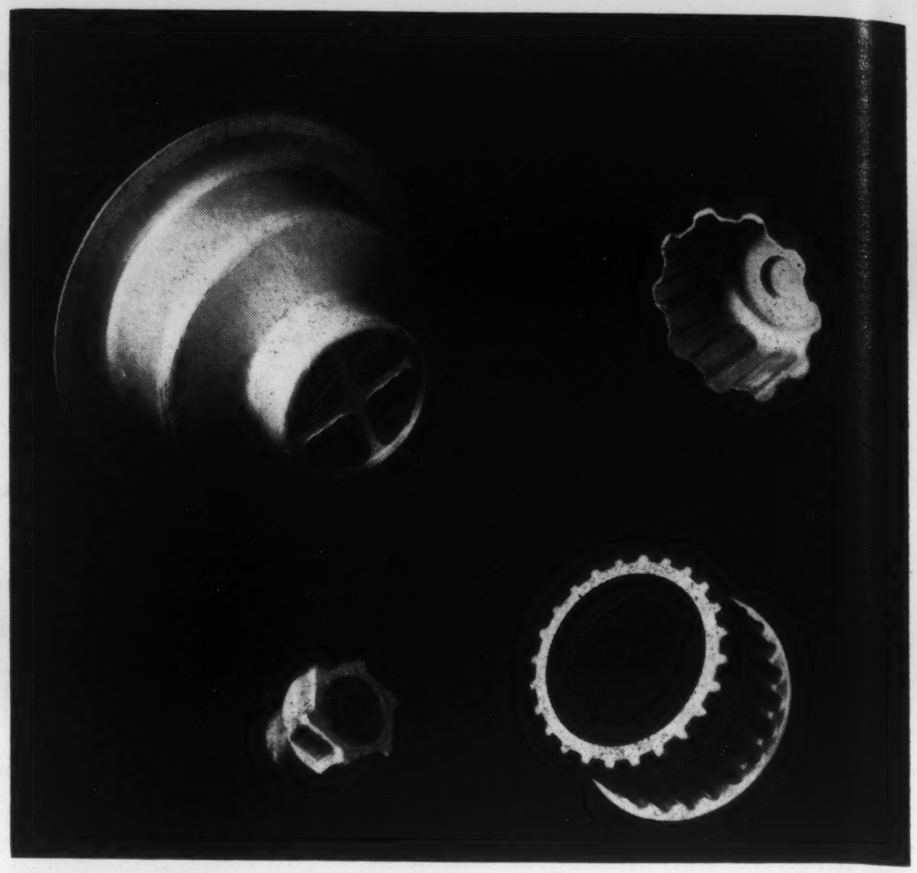
Ultrasonics is not the answer to every cleaning problem. There are some applications where entirely satisfactory cleaning can be obtained in a boiling solution. The addition of ultrasonic energy to such solutions does not provide any useful results because of the reduced effectiveness of cavitation. Soft spongy deposits are difficult to remove by ultrasonic cleaning; in such cases it is generally better to use high velocity jets or brushes. A follow-up ultrasonic bath can then be used to remove any residue remaining in difficult-to-reach areas.

The intensity of cavitation erosion is affected by the amount of gas entrapped in the cleaning liquid. Excessive gases are often encountered immediately after the liquid has been poured into the tank or after the addition of certain chemicals. Cleaning effectiveness is reduced until the combined effect of ultrasonic energy and higher temperatures partially degasses the liquid. In general, circulating systems should be designed so that little air is introduced into the tank. However, complete degassing of the liquid can be detrimental, as it has been found that much higher energy levels are required to cavitate a completely degassed liquid.

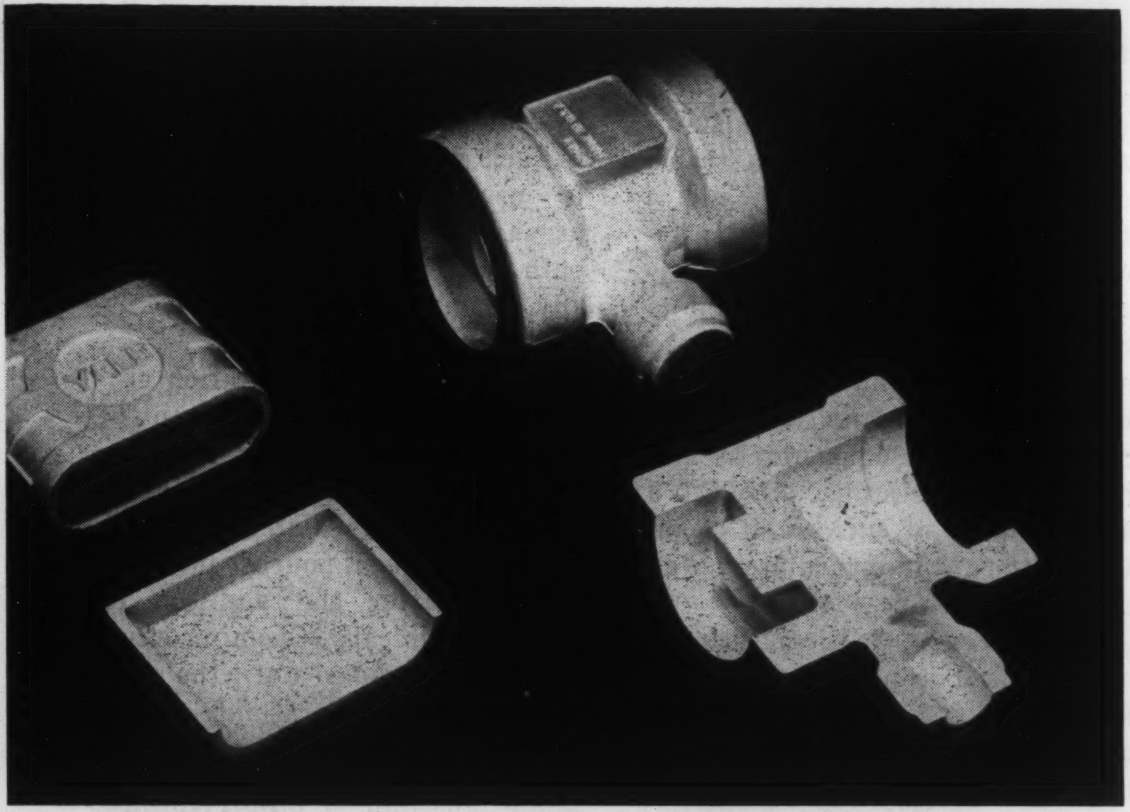
As mentioned previously, effective cleaning action is not produced in high viscosity liquids. Little cavitation is effected in these liquids, and the ultrasonic energy is wasted in raising the bath temperature.



Simple curved shapes can be produced.



Various contours are possible.



Machining is reduced by coring and no-draft cavities.

Designing for Cored Forgings

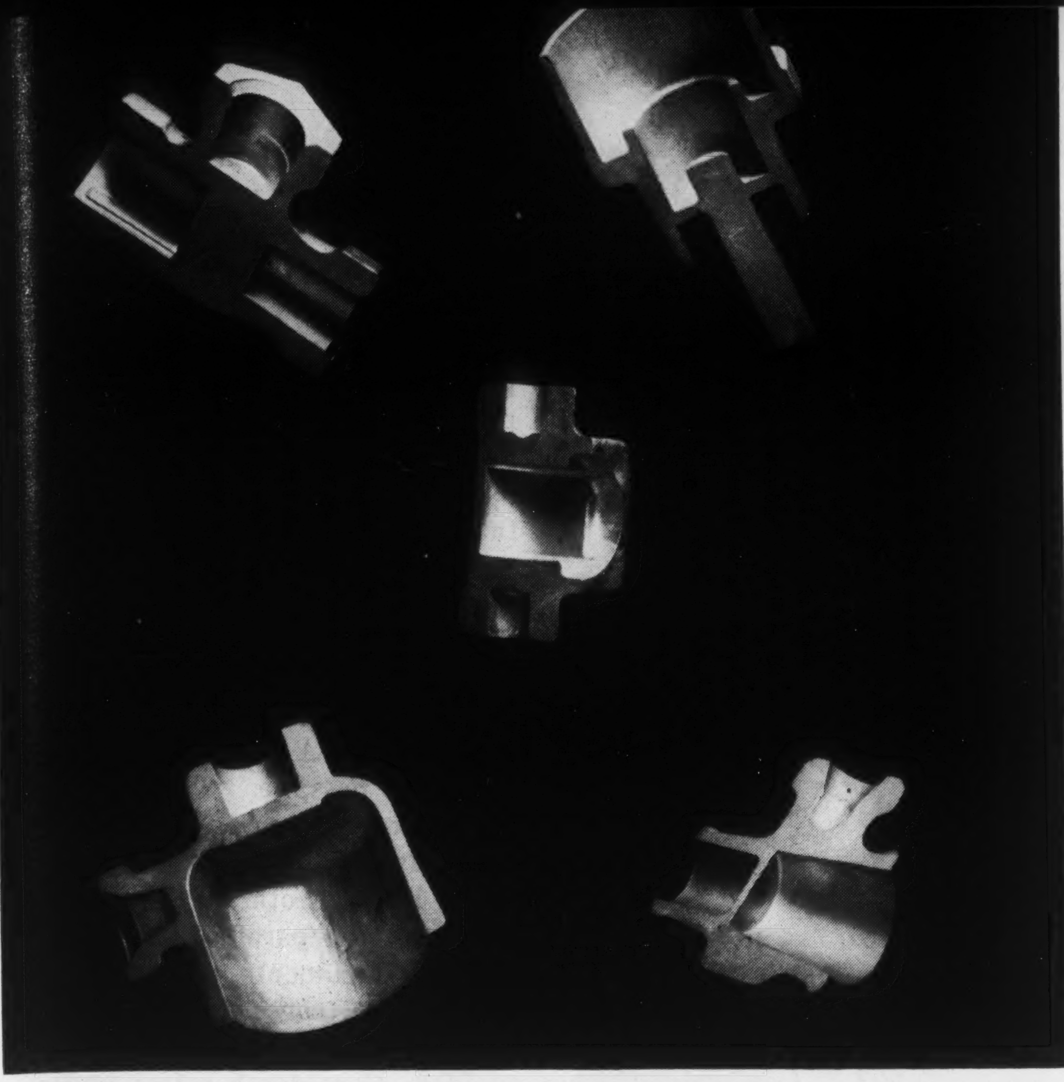
by **Carl J. Pfeifer**, *National Cored Forgings Div., Bridgeport Brass Co.*

■ Cored forging is a recently developed modification of conventional die forging that produces parts with cavities in a one step operation. It is said to be the quickest and most satisfactory method of producing brass hardware such as pipe fittings, valves and traps. Other parts include lock cylinders and cases, lens caps, gage cases, fire extinguisher parts, hose couplings, marine hardware and electrical connectors.

Advantages

A cored part has all of the advantages of a closed die forging, including excellent mechanical properties, dense structure free from internal flaws, good grain flow structure and good finish on both external and internal surfaces.

In addition a cored forging has



Up to four cores can be used, but coring must be done in one plane.

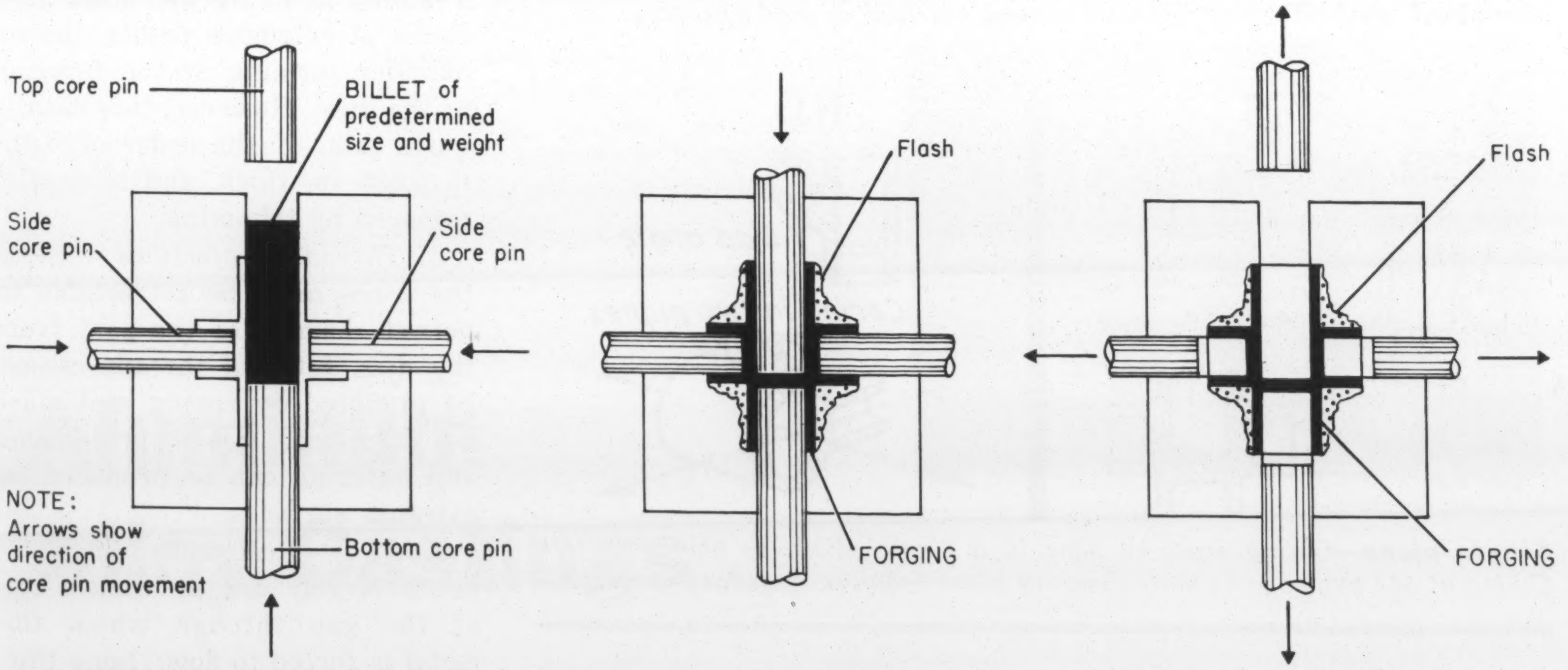
certain advantages over a closed die forging:

1. A cored forging is produced from a section of rod, whereas a closed die forging may require use of a preform.

2. Since length of the rod section must be closely controlled, the amount of excess metal that is eliminated as flash is reduced. Thus, flash generated in cored forging is thin—of the order of 0.020 in. in thickness—compared with flash on ordinary die forgings which may be 1/16 in. thick.

3. Machining is reduced because drilling can be eliminated or greatly reduced, close tolerances can be held, and holes can be produced without draft.

The result of thinner flash and reduced machining is a considerable reduction in scrap formation; savings in metal can range up to 50% of the metal required for


Top core pin
BILLET of predetermined size and weight
Side core pin
Side core pin
NOTE: Arrows show direction of core pin movement
Bottom core pin
Flash
FORGING
Flash
FORGING

1. Billet is placed *in die cavity and side and bottom core pins are moved into place.*

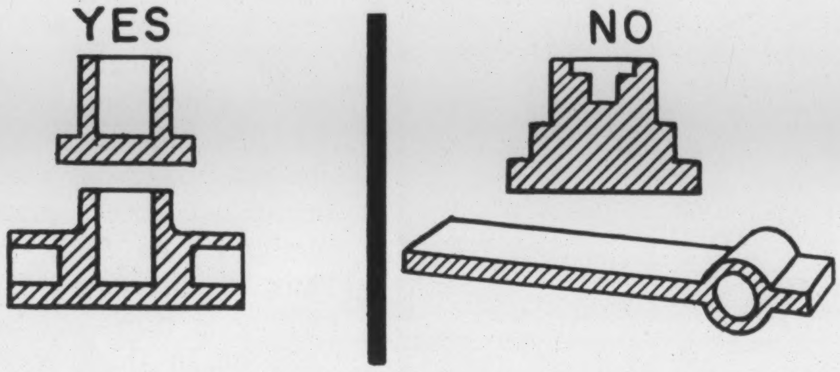
2. Top core pin moves *into extruded metal throughout die and around other core pins.*

3. Cores are withdrawn; *forging is ready for withdrawal and flash removal.*

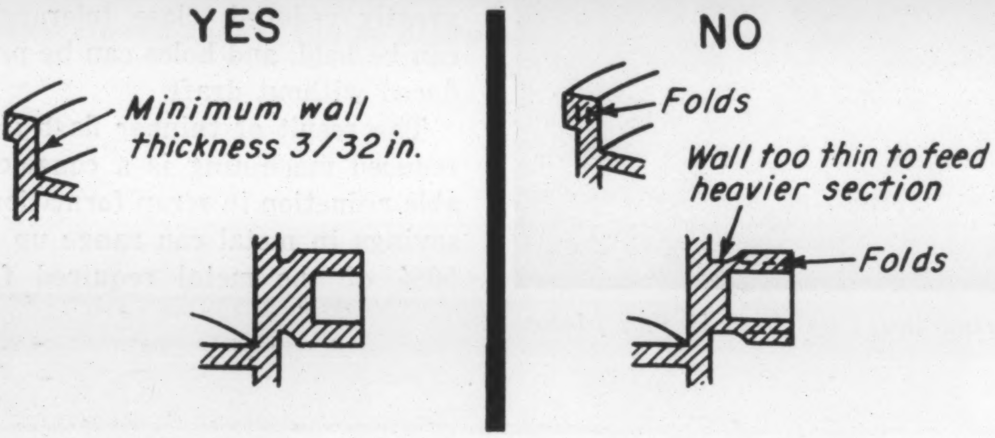
How a Cored Forging Is Produced

A cored forging is produced by a combination of closed die forging and extrusion. The special press required is equipped with mechanisms to introduce core pins, mechanically, immediately before pressure is exerted on the hot metal. The metal is forced to flow by displacement, filling the cavity and at the same time extruding around the cores to form cavities. Since the metal is under compression at all times, it can flow without the fracturing that would occur if flow occurred in the presence of tensile stresses. Cores are withdrawn before opening the dies to remove the part.

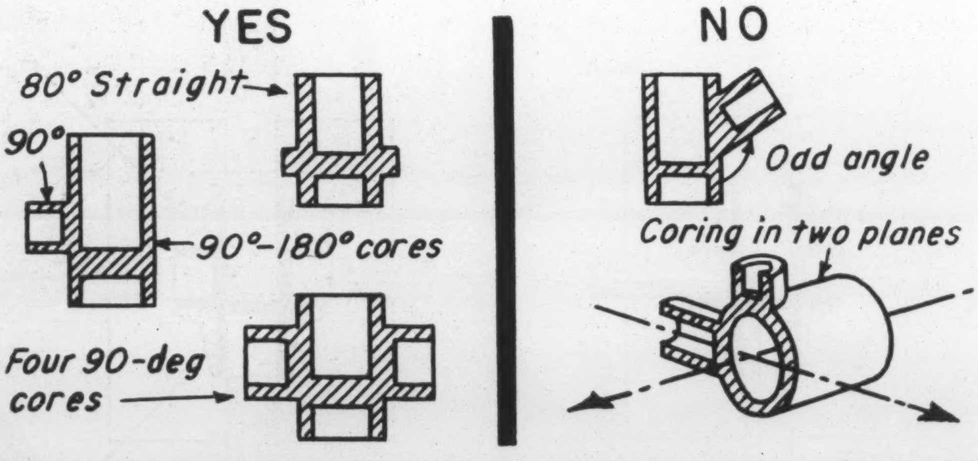
Some design factors



Large cores—*Cores must be large enough to do the work required in filling the die. Parts with small irregular cores or with large flat surfaces are not well suited to the process.*


YES
Minimum wall thickness 3/32 in.
NO
Folds
Wall too thin to feed heavier section
Folds

Constant wall—*Keeping the wall section constant is good practice.*



Single plane—*Coring must be done in a single plane, as shown at left. Coring at odd angles or in more than one plane requires secondary operations.*

closed die forging followed by machining.

A cored forging also has advantages over a sand casting. The forged part is pressure tight and free from internal flaws, and it is stronger and can be held to closer tolerances than the casting.

In comparison with metal powder parts, a cored forging can generally be produced with superior mechanical properties—particularly better ductility.

Materials

Cored forgings can be produced from forging brass, naval brass, red brass, commercial bronze, manganese bronze, aluminum bronze, silicon bronze, tough pitch copper and oxygen-free copper. Although most parts are produced from forging brass, any of the other alloys can be selected for specific properties. Thus naval brass might be selected because of its corrosion resistance, or aluminum bronze for a part requiring high strength.

Design considerations

In designing a part to be produced by cored forging, it is necessary to consider some of the possibilities and limitations of the process, if optimum results are to be obtained.

1. Size—The size of the part that can be produced depends on the press capacity. As a rule of thumb, it is safe to consider that the capacity must be 10 to 20 tons per sq in. of cross section, depending on the size.

2. Coring—A maximum of four cores is possible. These cores should be positioned 90 deg apart and must be in the same plane. Cored holes at other angles must be produced separately or require special attachments on the press. Long slender cores that may have a tendency to bend must be avoided. Core depth ratio: under 1 in. dia, 2 to 1; over 1 in. dia, 3 to 1.

3. Flash—Since cores must be a sliding fit in the die, some flash forms at extrusion points, the remainder forming at the junction of the dies. However, this flash is quite thin, of the order of 0.015 to 0.025 in. thick, and is readily removed by trimming.

4. Threads, projections—Since the cores must be retractable to permit removal of the part from the dies, internal threads cannot be produced by coring and must be machined. Small projections and lettering can be produced on external surfaces.

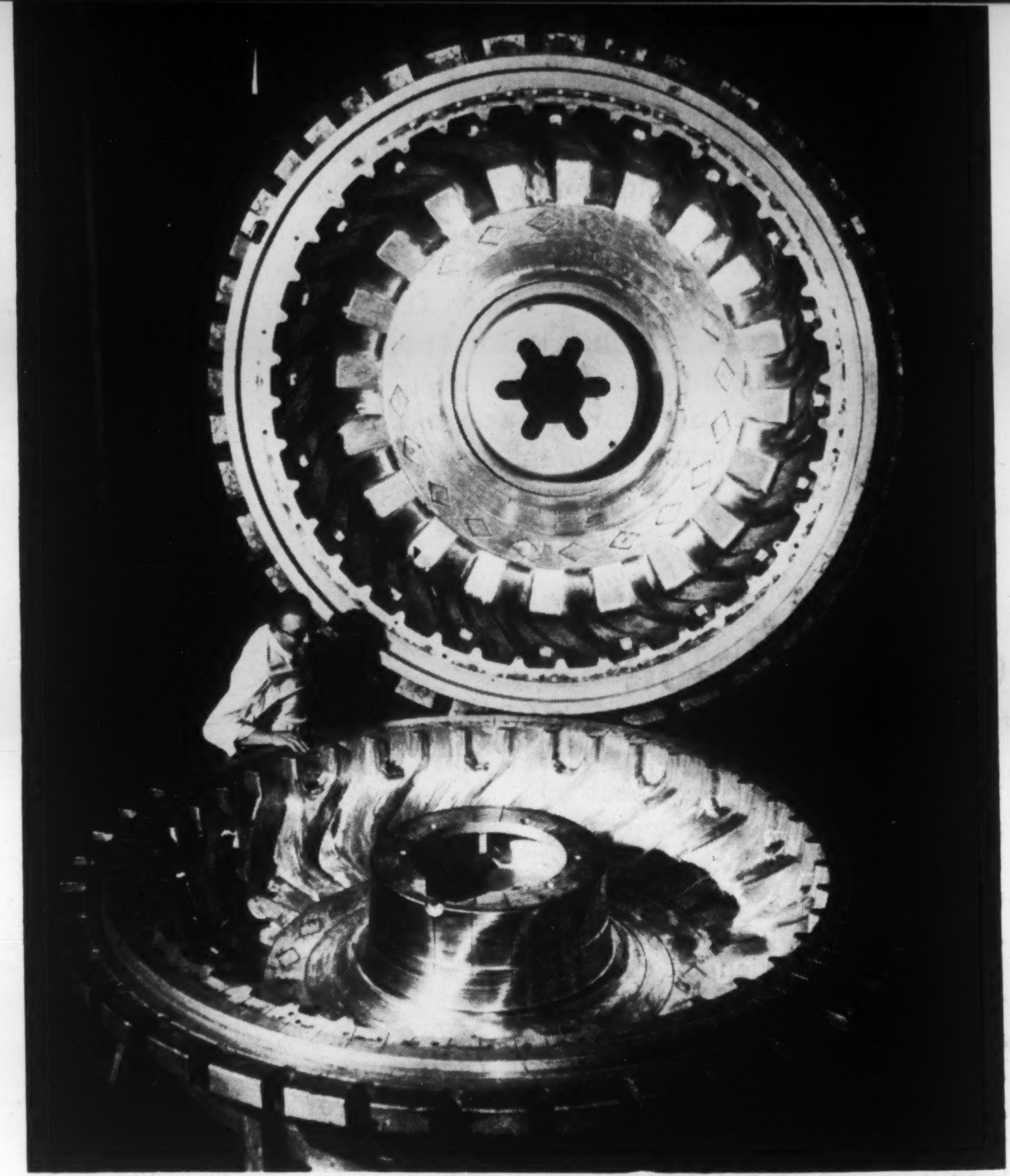
5. Walls—Resistance to flow depends largely on the dimensions of the gap through which the metal is forced to flow. Long thin flanges and thin walls are difficult to produce. Thus the minimum wall thickness is about 1/10 in. However, with wall thicknesses greater than this minimum it is possible to make an extruded section several inches long.

6. Tolerances—Dimensions can be held to ±0.005 in. in many cases. Machining allowances, when required, are presently held to ±0.020 in. on flat surfaces and ±0.040 in. on diameters.

Materials
in Design Engineering

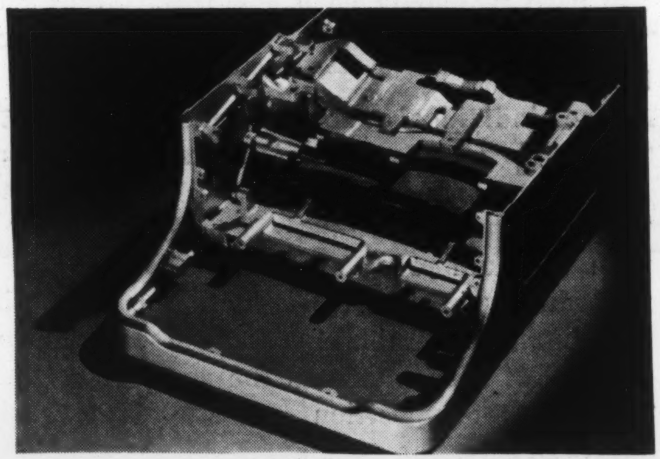
Manual No. 146
February 1958

by John L. Everhart,
Technical Editor,
Materials in Design Engineering



Photos Aluminum Co. of America

Large and small—*Huge tire mold back-up sections above are aluminum sand castings; each weighs 7500 lb. Typewriter frame at right consists of six aluminum-silicon alloy die castings.*



Aluminum Alloy Castings

About 30 of the wide variety of commercial aluminum alloys are used for castings. Some are suitable for all types of castings; others are restricted to a single type. This manual discusses sand, permanent mold and die castings, as well as investment and plaster mold castings. It should prove a useful summary of:

- *Specifications*
- *Engineering properties*
- *Design considerations*
- *Processing characteristics*
- *Applications*

The combination of light weight, resistance to corrosion, good mechanical properties, high electrical and thermal conductivities, and ease of finishing characteristic of aluminum alloy castings is responsible for their selection for a wide range of products—particularly for applications involving moving parts and assemblies.

Broadening use of aluminum castings has resulted in the development of many alloys to be used in this form, and the number of different alloys available makes selection of the proper alloy for a specific application something of a problem. This manual is intended to assist the engineer and designer by giving him sufficient information on the common casting alloys to permit him, at least tentatively, to select the casting process and narrow his choice of alloy. Consultation with the foundryman should then enable him to make a final decision on the best process and alloy for the purpose.

Classification

Although there are many aluminum alloys available, about 30 are in common use in the production of castings. These are covered by ASTM specifications. In general, this manual will be limited to a discussion of castings produced from this series of alloys. Their compositions and designations are given in Table 1. Some of the most widely used of these alloys are suitable for more than one casting process; others are used primarily with a single process.

Designations

The individual alloy designations follow the codification system covered in ASTM B275-55. This system is more satisfactory than the numbering system used in ordinary commercial practice (given also in Table 1) because the ASTM code indicates the approximate composition of the alloy. Briefly, the code symbol is derived as follows:

Designations for alloys consist of not more than two letters representing the alloying elements specified in greatest amount, arranged in order of decreasing percentages. If the elements occur in equal percentages, the arrangement is in alphabetical order. These letters are followed by the respective percentages rounded off to whole numbers. Finally, a serial letter is arbitrarily assigned, in alphabetical sequence, to differentiate between designations that would otherwise be identical.

Letters are assigned for a series of 19 alloying elements, but only the following are involved in the present group of standard casting alloys:

C—Copper
G—Magnesium
N—Nickel
S—Silicon
Z—Zinc

For example, ZG61A is a zinc (6%)-magnesium (1%) alloy and is the first of a series of designations that would otherwise be identical. ZG61B is the second of that series. Differences in composition can be determined by consulting Table 1.

Alloy groups

Aluminum-copper compositions were the earliest of the aluminum casting alloys and are still in limited use. Copper increases strength and hardness but does not improve foundry properties. Aluminum-silicon alloys have excellent casting properties and greater resistance to corrosion than the aluminum-copper alloys, but they have considerably lower strength. Thus, aluminum-copper-silicon alloys are becoming more widely used, as they make it possible to take advantage of the combination of properties imparted by the two elements. These alloys are particularly suited to the production of castings of intricate design having large differences in section thickness or requiring pressure tightness.

The aluminum-silicon alloys are widely used in marine work because of their excellent resistance to salt water and saline atmospheres. They are also used for decorative purposes because of their combination of resistance to atmospheric corrosion and the excellent castability that is essential in reproducing fine details. These alloys also resist mildly acidic solutions and are used extensively in the textile, wood and chemical industries.

The binary aluminum-magnesium alloys are the most resistant to corrosion of all the binary systems. Unfortunately, however, they are difficult to cast and therefore are not widely used. Instead, these magnesium alloys are generally modified by addition of silicon or zinc to improve castability.

Outstanding feature of the aluminum-silicon-magnesium alloys is a desirable combination of castability, pressure tightness, corrosion resistance and strength. These alloys can be heat treated to produce tensile properties comparable with those of the aluminum-copper alloys. The aluminum-silicon-magnesium alloys are outstanding for the production of intricate castings to be used in applications requiring high quality.

Zinc is not used in a simple binary casting alloy, but in combination with magnesium it produces several alloys having certain desirable characteristics. Natural aging at room temperature increases tensile and yield strengths, with accompanying loss in ductility. As a result, tensile properties are obtained that are equivalent to those produced by heat treating certain of the other alloys. These aluminum-magnesium-zinc alloys lose strength when heated to brazing temperatures but regain their original strength upon aging at room temperature for a few days. They do not have founding properties as good as those of some of the other alloys and are not recommended for intricate castings.

In addition to the standard alloys under discussion in this manual, there are many alloys that have been developed for specific, rather limited applications. Typical is an aluminum-2% manganese alloy that has excellent ductility and high resistance to slightly acidic solutions.

Engineering properties

Typical physical and mechanical properties of commonly used aluminum casting alloys are given in Tables 2, 3 and 4. There is not sufficient variation in physical properties (Table 2) in the group to make such factors as density, thermal expansion and conductivity particularly important in the selection of the alloy unless the application is highly specialized.

For all of these casting alloys, the modulus of elasticity in tension is 10,300,000 psi, the modulus of rigidity is 3,850,000 psi and Poisson's ratio is 0.33.

Mechanical properties

There is a rather wide range of mechanical properties, as shown in Table 3. In sand casting alloys, for example, tensile strengths ranging from 19,000 to 44,000 psi can be obtained; in permanent mold casting alloys, strengths up to 53,000 psi are possible. Ductility, as measured by elongation, varies widely—from a low of 0.5 to a high of 22%. There is also considerable variation in compressive properties. On the other hand, the fatigue strength varies in a rather narrow range and not as a relatively fixed ratio of the tensile

TABLE 1—COMPOSITION (%)

ASTM Alloy[a]	Commercial Designation	Cu	Si	Mg	Zn	Other
SAND CASTINGS						
C4A	195	4.5	—	—	—	—
CG100A	122	10.0	—	0.25	—	—
CN42A	142	4.0	—	1.5	—	2.0 Ni
CS43A	108	4.0	3.0	—	—	—
CS72A	113	7.0	2.5	—	—	—
G4A	214	—	—	4.0	—	—
G10A	220	—	—	10.0	—	—
GS42A	B214	—	1.8	4.0	—	—
S5A	43	—	5.25	—	—	—
S5B	43	—	5.25	—	—	—
SC51A	355	1.25	5.0	0.5	—	—
—	C355[b]	1.25	5.0	0.5	—	—
SC64B	319	3.8	6.25	—	—	—
SC64C	319	3.75	6.25	—	—	—
SC82A	327	1.5	7.8	0.4	—	0.4 Mn
SG70A	356	—	7.0	0.4	—	—
—	A356[b]	—	7.0	0.4	—	—
ZC81A	Tenzaloy	0.6	—	0.35	7.5	—
ZG32A	Ternalloy 5	—	—	1.6	3.0	0.5 Mn, 0.3 Cr
ZG42A	Ternalloy 7	—	—	2.1	4.25	0.5 Mn, 0.3 Cr
ZG61A	40E	—	—	0.6	5.5	0.5 Cr, 0.15 Ti
ZG61B	A612	0.5	—	0.7	6.5	—
PERMANENT MOLD CASTINGS						
CG100A	122	10.0	—	0.25	—	—
CN42A	142	4.0	—	1.5	—	2.0 Ni
CS42A	B195	4.5	2.5	—	—	—
CS66A	152	6.5	5.5	0.5	—	—
CS72A	113	7.0	2.5	—	—	—
CS104A	138	10.0	4.0	0.25	—	—
GS42A	B214	—	1.8	4.0	—	—
GZ42A	A214	—	—	4.0	1.8	—
S5A	43	—	5.25	—	—	—
S5B	43	—	5.25	—	—	—
SC51A	355	1.25	5.0	0.5	—	—
—	C355[b]	1.25	5.0	0.5	—	—
SC64A	A108	4.5	5.5	—	—	—
SC64B	319	3.8	6.25	—	—	—
SC64C	319	3.75	6.25	—	—	—
SC103A	—	3.0	9.5	1.0	—	—
SC122A	B132	1.5	12.0	0.7	—	0.7 Mn
SG70A	356	—	7.0	0.3	—	—
—	A356[b]	—	7.0	0.3	—	—
SN122A	A132	1.0	12.0	1.5	—	2.5 Ni
ZC60A	C612	0.5	—	0.35	6.5	—
ZC81B	Tenzaloy	0.7	—	0.35	7.5	—
ZG32A	Ternalloy 5	—	—	1.6	3.0	0.5 Mn, 0.3 Cr
ZG42A	Ternalloy 7	—	—	2.2	4.25	0.5 Mn, 0.3 Cr
DIE CASTINGS						
G8A	218	—	—	8.0	—	—
S5C	43	—	5.25	—	—	—
S12A[c]	13	—	12.0	—	—	1.3 Fe max
S12B	13	—	12.0	—	—	2.0 Fe max
SC84A[c]	A380	3.5	8.5	—	—	1.3 Fe max
SC84B	380	3.5	8.5	—	—	2.0 Fe max
SC114A[c]	384	3.75	11.25	—	—	1.3 Fe max
SG100A[c]	A360	—	9.5	0.5	—	1.3 Fe max
SG100B	360	—	9.5	0.5	—	2.0 Fe max

[a] Based on ASTM Specifications B26-56T, B108-56T, and B85-56T.

[b] C355 and A356 are new alloys not covered in ASTM specifications. They are lower iron modifications of 355 and 356.

[c] Die castings of these alloys may be made only in cold chamber machines.

strength as is the case in steels.

Properties given in these tables were determined on separately cast test bars. They do not necessarily reflect properties that will be found in tests on the actual casting. In castings having cross sections thinner than the standard test bar, tensile strength may be higher than the values given in the tables. On the other hand, castings with thicker sections may have lower strengths. However, the values can be used for design if proper allowances are made for the expected differences between test bars and the actual casting.

Many variables in casting technique can affect the actual mechanical properties obtained in a casting. These include such structural factors as internal soundness, microporosity and microshrinkage. By using high purity materials and exercising very careful control in melting and casting, it is possible to obtain properties considerably better than those reported in the tables. For example, guaranteed minimum properties required by Federal specifications for test bars cut from sand castings of type SG70A alloy are: 22,500 psi tensile strength, 15,000 psi yield strength and 0.75% elongation in 2 in. Castings are now available of the same alloy with guaranteed minimum properties, in the casting, of 33,000 psi tensile strength, 27,000 psi yield strength and 3.0% elongation in 2 in. Because of the careful control required in producing these castings, they are sold at a premium.

High temperature properties

Aluminum castings retain a considerable portion of their room temperature strength up to about 300 F, but above this temperature there is a rather rapid deterioration in most alloys. At 700 F, sand and permanent mold castings retain only a small fraction of their room temperature strengths, as shown in Table 4. Figures are not available for die castings at temperatures above 500 F, but the trend is similar.

With increasing temperature, ductility gradually increases and at 700 F is extremely high; in one sand casting alloy elongation reaches 100%.

Corrosion resistance

Aluminum alloys, in general, have good corrosion resistance, but alloys containing silicon or a combination of magnesium and silicon are superior in resistance to attack under many service conditions. The following brief discussion is based on the corrosion resistance of three of these alloys: S5A, GS42A and SG70A.

1. These alloys are resistant to concentrated nitric acid, chromic acid and most organic acids at ordinary temperatures. They are attacked by hydrochloric, dilute nitric, phosphoric and sulfuric acids, and by certain boiling organic acids such as acetic.

2. They resist attack by ammonium hydroxide but are attacked by sodium, potassium and calcium hydroxides in all concentrations.

3. They are resistant to many salts, including sodium bicarbonate and sodium, potassium, calcium and magnesium chlorides, sulfates and nitrates. They are attacked by salts of the heavy metals, including ferric chloride and nitrate, copper chloride and nitrate, mercury salts, silver salts and tin salts.

4. They are resistant to attack by rural, industrial and marine atmospheres, although SG70A is not quite as resistant to marine atmospheres as the other two alloys.

5. They also resist dry ammonia, wet or dry carbon dioxide, dry sulfur dioxide, oxygen and nitrogen. They are not resistant to wet chlorine or wet sulfur dioxide.

As is true with all corrosion data, these remarks should be taken only as a qualitative evaluation of the resistance of the alloys to corrosive environments. So many factors affect resistance to attack that the only proper manner of selecting an alloy is a test under the specific conditions of exposure.

Types of Castings

Aluminum alloys can be cast by practically all methods, but 95% of aluminum castings are made by sand casting, permanent mold casting or die casting. Some qualitative comparisons of these methods are given below and in Tables 5 on p 11.

Sand castings

Sand casting is the most flexible method. It is generally used for large castings, intricate castings and castings of all types produced in quantities too small to justify the expense of preparing a metal mold or die. Sand casting is also used for long production runs of small castings that can be grouped for use of modern high speed molding equipment. Aluminum alloy sand castings ranging in size from a few ounces to 1500 lb are in regular production, and castings weighing up to 7000 lb have been produced.

Pemanent mold castings

Permanent mold casting is a mass production operation and is particularly suited to the production of large numbers of identical castings. Usually several thousand units must be required to justify the expense of the metal mold but, in special cases, it has been economical to produce only a few hundred units.

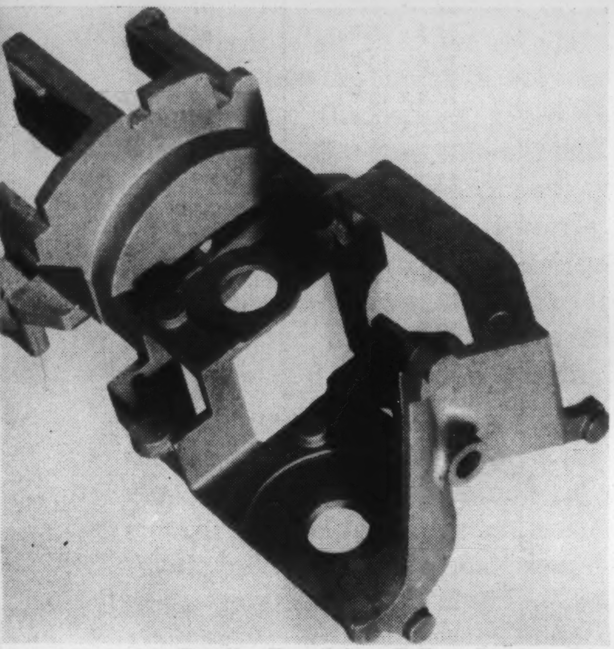
In general, permanent mold castings are more uniform, can be held to closer dimensional tolerances, and have better pressure tightness and smoother surfaces than sand castings. Mechanical

TABLE 2—TYPICAL PHYSICAL PROPERTIES

Alloy	Condition	Density, lb/cu in.	Solidification Temp Range, F	Ther Cond (68 F), Btu/hr/sq ft/°F/ft	Coef of Ther Exp (68-212 F), per °F	Elec Cond, % IACS
SAND CASTING ALLOYS						
C4A	Solution Heat Treated	0.101	1195-1020	80	12.7 x 10^{-6}	35
	Solution Treated and Aged	0.101	1195-1020	85	12.7 x 10^{-6}	37
CG100A	Annealed	0.103	1160-1005	92	12.2 x 10^{-6}	41
	Solution Treated and Aged	0.103	1160-1005	75	12.2 x 10^{-6}	33
CN42A	Annealed	0.101	1165-995	97	12.5 x 10^{-6}	44
CS43A	As Cast	0.100	1160-970	70	12.2 x 10^{-6}	31
	Annealed	0.100	1160-970	85	12.2 x 10^{-6}	38
CS72A	As Cast	0.102	1165-975	64	12.2 x 10^{-6}	27
G4A	As Cast	0.095	1185-1075	80	13.3 x 10^{-6}	35
G10A	Solution Heat Treated	0.093	1150-840	51	13.6 x 10^{-6}	21
GS42A	As Cast	0.095	1170-1090	85	13.0 x 10^{-6}	38
S5A	As Cast	0.097	1175-1070	85	12.2 x 10^{-6}	38
S5B	As Cast	0.097	1175-1070	85	12.2 x 10^{-6}	38
SC51A	Artificially Aged	0.097	1160-1075	97	12.2 x 10^{-6}	43
	Solution Treated and Aged	0.097	1160-1075	83	12.2 x 10^{-6}	36
C355[a]	Solution Treated and Aged	0.097	1160-1075	—	12.4 x 10^{-6}	—
SC64B	As Cast	0.100	1120-950	65	12.0 x 10^{-6}	27
SC82A	As Cast	0.096	1110-1055	65	11.9 x 10^{-6}	29
SG70A	Artificially Aged	0.096	1130-1075	97	11.9 x 10^{-6}	43
	Solution Treated and Aged	0.096	1130-1075	87	11.9 x 10^{-6}	39
A356[a]	Solution Treated and Aged	0.097	1130-1075	—	11.9 x 10^{-6}	—
ZC81A	As Cast	0.100	—	—	14.0 x 10^{-6}	—
ZG32A	As Cast	0.100	1175-1030	—	13.1 x 10^{-6}	—
ZG42A	As Cast	0.100	1170-1020	—	13.2 x 10^{-6}	—
ZG61A	As Cast	0.100	1140-1060	—	13.7 x 10^{-6}	25
ZG61B	As Cast	0.101	1195-1105	80	13.4 x 10^{-6}	35
PERMANENT MOLD CASTING ALLOYS						
CG100A	As Cast	0.103	1160-1005	77	12.2 x 10^{-6}	34
CN42A	Artificially Aged	0.101	1165-995	77	12.5 x 10^{-6}	34
	Solution Treated and Aged	0.101	1165-995	77	12.5 x 10^{-6}	33
CS42A	Solution Heat Treated	0.100	1160-980	80	12.2 x 10^{-6}	35
	Solution Treated and Aged	0.100	1160-980	105	12.2 x 10^{-6}	50
CS66A	As Cast	0.101	1160-930	58	—	24
CS72A	As Cast	0.102	1165-975	67	12.2 x 10^{-6}	30
CS104A	As Cast	0.103	1120-940	60	11.9 x 10^{-6}	25
GS42A	As Cast	0.095	1170-1090	84	12.7 x 10^{-6}	38
	As Cast	0.095	1180-1050	77	13.3 x 10^{-6}	34
S5A	As Cast	0.100	1170-1065	82	12.3 x 10^{-6}	37
S5B	As Cast	0.100	1170-1065	94	12.3 x 10^{-6}	42
SC51A	As Cast	0.097	1160-1070	87	—	39
C355[a]	Solution Treated and Aged	0.098	1160-1070	82	12.4 x 10^{-6}	37
SC64A	As Cast	0.100	1140-960	82	11.9 x 10^{-6}	37
SC64B	As Cast	0.099	1120-950	67	—	29
SC64C	As Cast	0.100	1120-960	63	12.0 x 10^{-6}	27
SC122A	As Cast	0.096	1060-1055	63	11.2 x 10^{-6}	28
SG70A	Solution Treated and Aged	0.096	1130-1075	92	11.9 x 10^{-6}	41
A356[a]	Solution Treated and Aged	0.097	1130-1075	92	11.9 x 10^{-6}	41
SN122A	Artificially Aged	0.098	1095-1000	67	10.5 x 10^{-6}	29
ZC60A	As Cast	0.102	1190-1120	89	13.1 x 10^{-6}	40
ZC81B	As Cast	0.100	—	—	14.0 x 10^{-6}	—
ZG32A	As Cast	0.100	1175-1030	—	13.1 x 10^{-6}	—
ZG42A	As Cast	0.100	1170-1020	—	13.2 x 10^{-6}	—
DIE CASTING ALLOYS						
G8A	As Cast	0.093	1150-995	56	13.3 x 10^{-6}	24
S5C	As Cast	0.097	1175-1070	84	12.2 x 10^{-6}	38
S12A	As Cast	0.097	1085-1065	70	11.4 x 10^{-6}	31
S12B	As Cast	0.097	1085-1065	70	11.4 x 10^{-6}	33
SC84A	As Cast	0.097	1100-1000	58	11.7 x 10^{-6}	25
SC84B	As Cast	0.097	1100-1000	56	11.6 x 10^{-6}	23
SC114A	As Cast	0.097	1080-960	56	11.2 x 10^{-6}	23
SG100A	As Cast	0.095	1095-1050	70	11.7 x 10^{-6}	30
SG100B	As Cast	0.095	1105-1035	68	11.6 x 10^{-6}	28

[a] Commercial designation.

Die castings are used for . . .

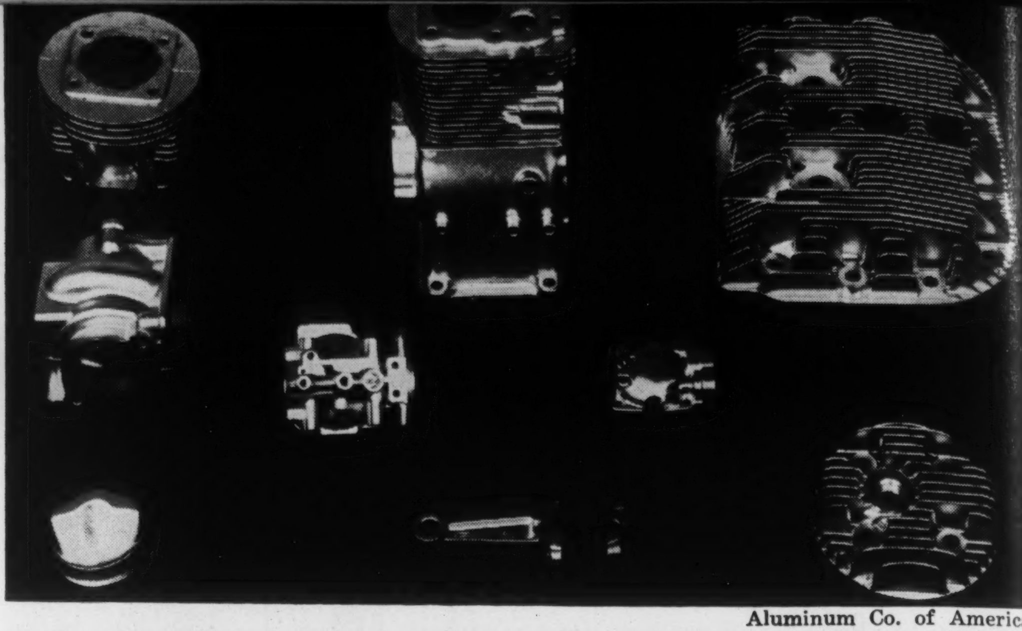


Bendix Foundries, Eclipse-Pioneer Div.

Aircraft instrument frames—*Main frame of a course indicator, die cast from alloy S12A in one piece, replaced an assembly of three castings.*

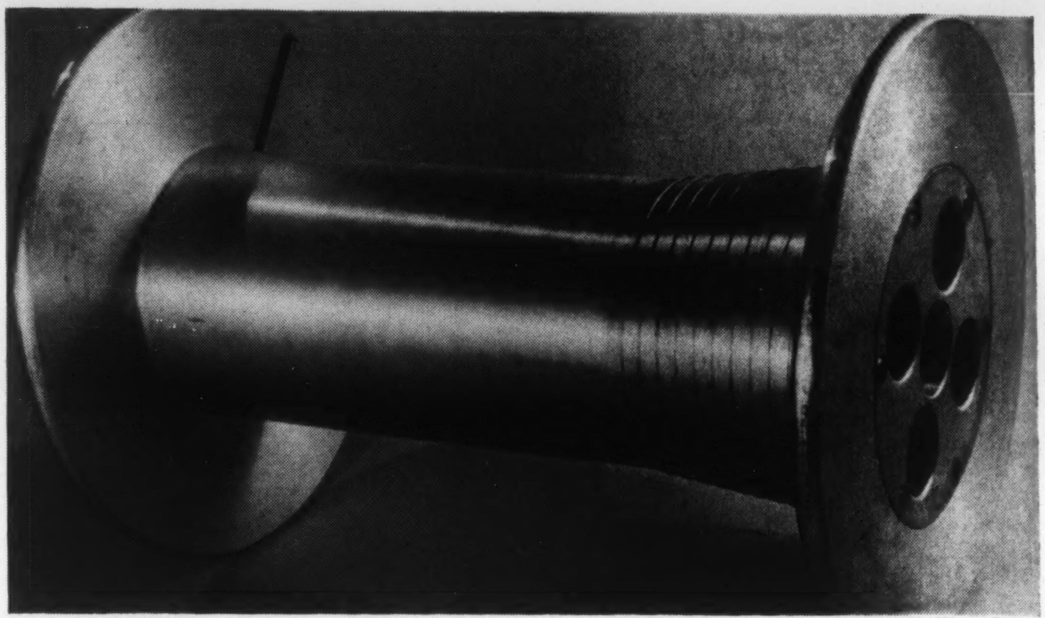
Aluminum Co. of America

Meat grinder parts—*These parts are ball burnished after casting.*



Aluminum Co. of America

Parts for small engines—*Cylinder bodies and heads, crankshafts, pistons and carburetor parts are produced by die casting.*



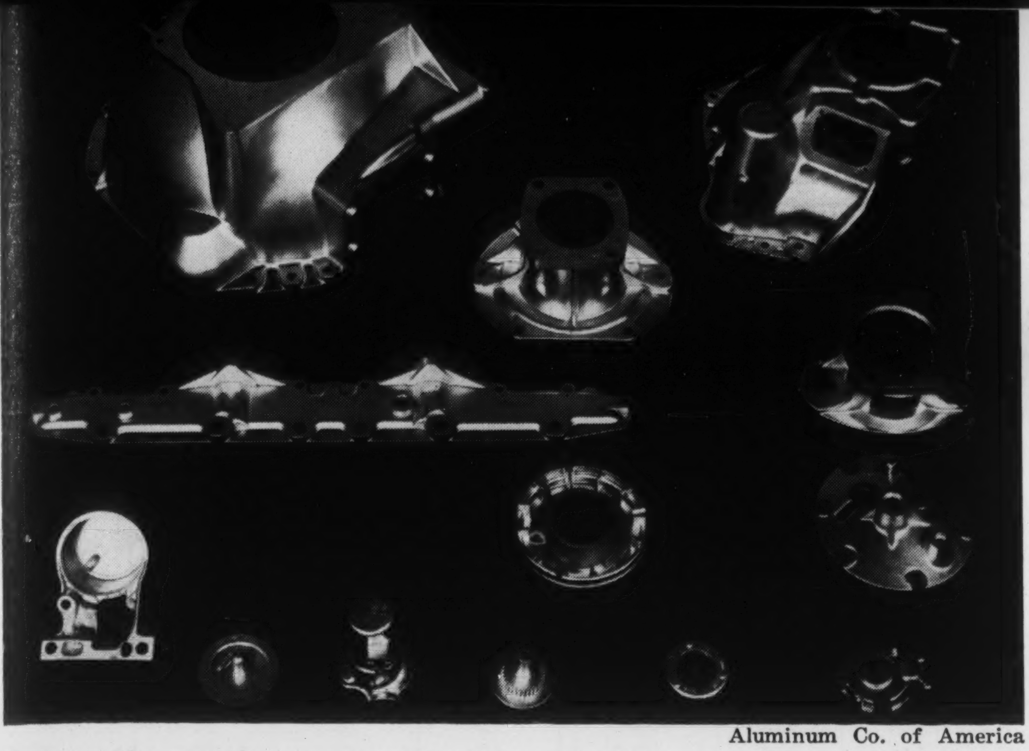
Dollin Corp.

Bobbins and spools—*Die cast bobbin produced from SC84A is used in manufacture of viscose rayon. Aluminum alloy bobbin costs 25% less than the fibre bobbin used previously and has long service life; the fibre bobbin required yearly replacement.*

properties are usually higher also. Because of these characteristics, it is possible to reduce the metal requirements for the same design stress where permanent mold castings replace sand castings. Lower machining and finishing costs are possible also because of the smoother surfaces and closer dimensional tolerances of permanent mold castings. Permanent mold castings weighing from a few ounces up to 300 lb are in regular production. Larger castings have been made.

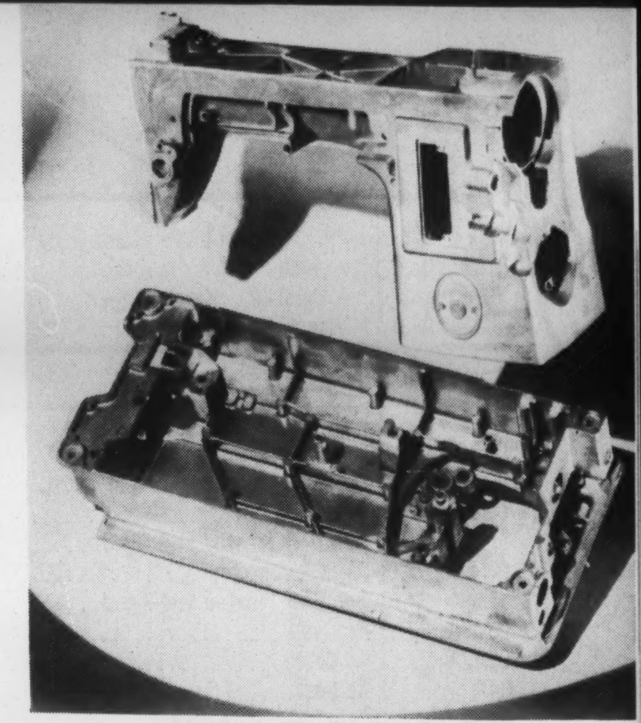
Die castings

Die casting is also a mass production method. It is superior to either of the other major processes in reproduction of surface finish and surface detail. The die casting process is particularly suited to casting thin sections, to obtaining dimensional accuracy, and to low cost production. Cost savings result from the use of thin sections which substantially reduce the quantity of metal required per part. Finishing costs are minimized because of high dimensional accuracy, smooth surfaces and the possibility of casting threads. Die castings in regular production range from a fraction of an ounce to about 75 lb in weight.



Aluminum Co. of America

Automotive engine parts—*Housings and other parts for automatic transmissions are shown here.*



American Die Casting Institute

Sewing machine parts—*Base and upper frame were redesigned from iron sand castings to aluminum die castings to reduce weight of machine.*

Design Considerations

The principles of casting design applicable to other materials are generally applicable to aluminum. A detailed discussion is not possible in this manual but the information is available in a number of publications, notably in the *Cast Metals Handbook.*

It is highly desirable for the engineer to consult the foundryman during the early stages of design. Consultations of this type will develop the best method for producing the desired part and may result in modifications that reduce costs. However, certain considerations applying specifically to aluminum castings are discussed below:

Section thickness

Section thickness should be uniform, if possible, particularly in permanent mold and die castings. If the design calls for variations in thickness, the change should be gradual instead of abrupt. Sections should have a minimum thickness of 1/8 to 3/16 in. for sand castings, ⅛ in. over small areas for permanent mold castings, and 0.045 to 0.075 in. for die castings.

Draft

Designs must include allowance for draft. In sand castings, sufficient taper (draft)—at least 1/16 in. per ft—must be provided on all vertical faces to permit withdrawal of the pattern from the sand mold. The engineering drawing should indicate whether the allowance is to be added to or subtracted from the dimensions.

In permanent mold casting design, draft is required to permit removal of the casting from the mold. In these molds, the metal has a tendency to shrink from the outer surfaces and toward the inner ones. Therefore more draft is required on the inner than on the outer surface; taper ranges from 2 to 5 deg on inner surfaces, from 1 to 3 deg on the outer.

Sufficient draft is also required on die castings to permit removal of the part. Draft ranges from 0.020 in. per in. of depth for ⅛-in. dia round holes to 0.012 in. per in. for 1-in. dia holes. For holes with square or rectangular cross sections, draft can be the same as that required for a round hole having a diameter equal to the distance between opposite faces. Draft on outside surfaces can be half that on inside surfaces.

Shrinkage

To compensate for contraction of the casting during freezing and cooling, the pattern must be larger than the desired casting. Depending on such factors as casting design, the particular alloy, and the resistance to contraction offered by the mold and core, shrinkage allowances range from 1/10 to 5/32 in. per ft for sand castings. Less allowance is required for permanent mold and die castings.

Finishing allowance

The excess material required for finishing to proper dimensions depends on casting method, size of casting, machining method and similar factors.

To finish sand castings on lathes or milling machines, for example, requires an allowance of ⅛ in. for small to medium size castings, and ¼ in. or more for large castings.

Permanent mold castings, having smoother surfaces and greater dimensional accuracy, require less

TABLE 3—TYPICAL MECHANICAL PROPERTIES

Alloy	Condition	Yield Strength (0.2% offset), 1000 psi	Tensile Strength, 1000 psi	Elongation (in 2 in.), %	Brinell Hardness	Compr Yield Strength, (0.2% offset), 1000 psi	Shear Strength, 1000 psi	Fatigue Strength, 1000 psi[a]
SAND CASTING ALLOYS								
C4A	Solution Heat Treated	16	32	8.5	60	16	24	6
	Solution Heat Treated and Aged	30	40	2.0	95	38	31	7
CG100A	Aged	20	27	1.0	80	20	21	9.5
	Solution Treated and Aged	30	40	0.5	115	43	29	8.5
CN42A	Aged	18	27	1.0	70	18	21	6.5
	Solution Treated and Aged	25	28	2.0	75	—	24	9.5
CS43A	As Cast	14	19	1.5	—	—	—	—
CS72A	As Cast	15	24	1.5	70	17	20	9
G4A	As Cast	12	25	9.0	50	12	20	5.5
G10A	Solution Heat Treated	25	46	14	75	26	33	7
GS42A	As Cast	13	20	2.0	50	15	17	—
S5A	As Cast	9	19	6.0	40	10	14	6.5
S5B	As Cast	9	19	6.0	40	10	14	6.5
SC51A	Artificially Aged	23	28	1.5	65	24	22	7
	Solution Treated and Aged	25	35	2.5	80	29	30	8.5
	Solution Treated and Aged	29	35	1.5	75	—	—	10
SC64B	As Cast	18	27	2.0	70	18	—	10
	Solution Treated and Aged	24	36	2.0	80	24	—	10
SC64C	As Cast	18	23	—	—	—	—	—
	Solution Treated and Aged	24	31	1.5	—	—	—	—
SC82A	Solution Heat Treated	20	33	2.9	82	—	—	—
	Solution Treated and Aged	28	36	2.0	81	20	—	—
SG70A	Artificially Aged	20	25	2.0	60	28	—	—
	Solution Treated and Aged	24	33	4.0	60	22	18	7.5
ZC81A	Artificially Aged	25	35	4.5	70	24	27	8
ZG32A	As Cast	13	29	12	—	—	—	—
	Artificially Aged	19	35	9.0	50	—	—	—
ZG42A	As Cast	19	30	5.0	65	—	—	—
	Artificially Aged	27	37	3.0	65	—	—	—
	Solution Heat Treated	40	44	1.5	85	—	—	—
	Solution Treated and Aged	38	43	1.5	80	—	—	—
ZG61A	Artificially Aged	25	32	3.0	75	25	26	9
ZG61B	As Cast	—	32	2.0	—	—	—	—
PERMANENT MOLD CASTING ALLOYS								
CG100A	Artificially Aged	35	37	0.5	115	40	27	8.5
	Solution Treated and Aged	36	48	0.5	140	36	30	9
CN42A	Artificially Aged	34	40	1.0	105	34	26	10.5
	Solution Treated and Aged	42	47	0.5	110	46	31	9.5

[a] Based on 5×10^8 cycles of completely reversed stress.

[b] Commercial designation.

machining and allowances can be reduced. Requirements range from 1/32 to 1/16 in. for small and medium size castings up to ⅛ in. for large castings.

The surfaces on die castings are sufficiently smooth for many applications to require machining only for removal of flash. In any case, machining should be held to an absolute minimum to prevent removal of the dense surface layer that is characteristic of castings produced by this method.

Coring

For sand castings, cores should be integral with the mold if design permits. Separate cores should be as simple as possible. Long thin cores should be avoided because of danger of breakage unless special techniques are used. Replacement of sand cores by metal or glass tubing has been employed successfully in producing long, cored small diameter passages that could not be produced by sand coring. The glass or metal cores are dissolved after the casting is produced. The minimum diameter of long cored holes produced with sand cores is about ¼ in.; by using tubing methods, cored holes ⅛ in. in dia can be obtained.

In permanent mold casting, the metal cores are withdrawn from the mold before removal of the casting. Coring may become difficult if the design is complicated, and sand cores can be used (semi-permanent mold method). Design changes should be made, if possible, to eliminate complicated

TABLE 3—TYPICAL MECHANICAL PROPERTIES—continued

Alloy	Condition	Yield Strength (0.2% offset), 1000 psi	Tensile Strength, 1000 psi	Elongation (in 2 in.), %	Brinell Hardness	Compr Yield Strength, (0.2% offset), 1000 psi	Shear Strength, 1000 psi	Fatigue Strength, 1000 psi[a]
PERMANENT MOLD CASTING ALLOYS-continued								
CS42A	Solution Heat Treated	22	37	9.0	75	22	30	9.5
	Solution Treated and Aged	26	40	5.0	90	26	32	—
	Solution Treated and Aged	20	39	4.5	80	20	—	—
CS66A	Artificially Aged	16	29	1.0	95	16	22	—
CS72A	As Cast	19	28	2.0	70	19	23	—
CS104B	As Cast	24	32	1.5	100	32	22	—
GZ42A	As Cast	16	27	7.0	60	17	22	—
SC51A	Solution Treated and Aged	27	43	4.0	90	27	30	9.0
C355[b]	Solution Treated and Aged	34	46	6.0	—	—	33	13.0
SC64A	As Cast	16	28	2.0	70	16	25	—
SC64B	As Cast	19	34	2.5	85	19	24	—
	Solution Treated and Aged	27	40	3.0	95	27	—	—
SC64C	As Cast	19	26	—	—	—	—	—
SC82A	Solution Treated and Aged	40	49	3.0	97	—	—	—
SC122A	Solution Heat Treated	27	41	2.5	90	27	—	—
	Artificially Aged	26	40	0.3	97	26	—	—
SC122A	Solution Treated and Aged	38	43	1.0	92	38	—	—
SG70A	Solution Treated and Aged	27	40	5.0	90	24	—	—
A356[b]	Solution Treated and Aged	30	41	10	90	—	35	10
SN122A	Artificially Aged	28	36	0.5	105	28	24	—
	Solution Treated and Aged	43	47	0.5	125	43	27	—
ZC60A	Aged	—	28	7.0	—	—	—	—
ZC81B	Artificially Aged	27	40	6.0	74	—	—	—
ZG32A	As Cast	15	33	22	55	—	—	—
	Artificially Aged	21	42	18	70	—	—	—
ZG42A	As Cast	24	42	14	75	—	—	—
	Artificially Aged	29	47	8.0	95	—	—	—
	Solution Heat Treated	36	49	9.5	95	—	—	—
	Solution Treated and Aged	43	53	6.5	95	—	—	—
DIE CASTING ALLOYS								
G8A	As Cast	27	45	8.0	—	27	27	23
S5C	As Cast	16	30	9.0	—	16	19	17
S12A	As Cast	21	39	2.0	—	21	25	19
S12B	As Cast	—	37	1.8	—	—	—	—
SC84A	As Cast	25	46	3.0	—	25	29	19
SC84B	As Cast	26	45	2.0	—	26	29	20
SG100A	As Cast	27	44	3.0	—	27	28	19
SG100B	As Cast	—	43	3.0	—	—	—	—

coring. Minimum diameter of cored holes is about ¼ in.

Die casting designs should incorporate coring to the largest possible extent to promote structural soundness, provide uniform wall thickness and save metal. Simple cores are desirable. If possible, they should be placed parallel to the direction of die motion, because such cores can be permanently attached to either half of the mold. Cores not parallel to the direction of die motion introduce complications and should be avoided if the design permits. Long cores should be avoided unless they can be guided into the other half of the die. The minimum diameter of cored holes in die castings is about 3/32 in.

Dimensional tolerances

Designers should recall that specifying dimensions to closer tolerances than necessary will increase the cost of the part and may reduce production rates. Therefore, close tolerances should be specified only on critical dimensions, and liberal tolerances should be permitted wherever they will not affect the part's function.

In sand castings, dimensional accuracy varies with factors such as type of molding equipment, use of hand or machine ramming, pattern design and skill of the molder. Generally, commercial tolerances range from ±1/16 to ±1/32 in. per ft.

Dimensional tolerances can be held much closer in permanent mold casting. Generally, they range from ±0.02 to ±0.05 in. per ft, but it is possible to hold

TABLE 4—TYPICAL MECHANICAL PROPERTIES AT

Temperature, F ➡	75			212			300		
Alloy and Temper ⬇	Yld Str (0.2% offset), 1000 psi	Ten Str, 1000 psi	Elong (2 in.), %	Yld Str (0.2% offset), 1000 psi	Ten Str, 1000 psi	Elong (2 in.), %	Yld Str (0.2% offset), 1000 psi	Ten Str, 1000 psi	Elong (2 in.), %
SAND CASTINGS									
C4A-T6	24	36	5.0	23	34	5.0	20	28	5.0
CG100A-T61	40	41	<0.5	38	39	0.5	35	36	1.0
CN42A-T571	30	32	0.5	30	32	0.5	30	31	0.5
CN42A-T77	23	30	2.0	23	30	2.0	22	28	2.0
G4A	12	25	9.0	12	24	9.0	12	22	7.0
SC51A-T51	23	28	1.5	22	28	2.0	20	25	2.5
SC51A-T6	25	35	3.0	25	35	2.0	25	33	1.5
SC51A-T71	29	35	1.5	28	33	2.0	25	29	3.0
SG70A-T6	24	33	3.5	23	29	4.0	21	25	5.0
SG70A-T7	30	34	2.0	28	29	2.5	24	25	3.0
PERMANENT MOLD CASTINGS									
CN100A-T551	35	37	<0.5	33	34	<0.5	27	30	<0.5
CN42A-T571	34	40	1.0	34	40	1.0	33	37	1.0
CS42A-T6	26	40	5.0	23	35	5.0	23	29	5.0
SC51A-T6	27	43	4.0	27	39	3.0	27	33	2.5
SC51A-T71	31	36	3.0	28	32	3.0	22	27	4.0
SG70A-T6	27	40	5.0	24	29	10	19	20	15
SG70A-T7	24	33	5.0	22	28	10	19	20	15
SN122A-T551	28	36	0.5	25	35	1.0	22	31	1.0
DIE CASTINGS									
G8A	27	45	8.0	25	40	8.0	21	32	15
S5C	16	30	9.0	16	26	9.0	15	20	10
S12B	21	39	2.0	21	34	2.5	18	27	3.0
SC84A	21	42	3.0	22	38	3.0	19	27	6.0
SC84B	26	45	2.0	28	43	3.0	22	31	4.0
SC114A	27	46	1.0	28	44	0.5	23	36	1.5
SG100A	23	41	5.0	23	36	3.0	21	32	5.0
SG100B	27	44	3.0	27	39	2.0	23	33	4.0

[a] **This table gives lowest strength resulting from heating 10,000 hr at testing temperature.**

dimensions closer than these. Straight cored holes can be held between +0.005 and -0.01 in. of specified dimensions.

Die casting tolerances are closer than permanent mold casting tolerances. Minimum tolerances are about ±0.0015 to ±0.002 in. Requirements on dimensions crossing parting lines cannot be held so closely, however, and may range up to ±0.010 in.

Other factors

Because they involve casting difficulties, large flat areas should be avoided; a slightly curved design can frequently be substituted. To increase strength, sections can be stiffened with reinforcing ribs. These ribs should have flat edges and should be about 1½ times as thick as supporting sections. Generous fillets should be provided in designs of this kind.

Processing Characteristics

A number of operations performed on the part after it is cast require consideration. These include machining, heat treating, joining, cleaning and finishing.

Machinability

Aluminum alloy castings can be machined at high speeds using standard shop tools. In general, alloys containing copper, zinc and/or magnesium are more readily machinable than those containing silicon.

High speed steel tools can be used for most alloys, but carbide-tipped tools should be used with alloys of high silicon content. These tools should be ground with greater side and top rake angles than are used for steel. In general, side rake varies from 10 to 20 deg, although larger angles can be used in planing, shaping and finishing operations. The top rake ranges from 20 to 50 deg, the greater angle producing the smoother finish. Because of these

ELEVATED TEMPERATURES[a]

400			500			600			700		
Yld Str (0.2% offset), 1000 psi	Ten Str, 1000 psi	Elong (2 in.), %	Yld Str (0.2% offset), 1000 psi	Ten Str, 1000 psi	Elong (2 in.), %	Yld Str (0.2% offset), 1000 psi	Ten Str, 1000 psi	Elong (2 in.), %	Yld Str (0.2% offset), 1000 psi	Ten Str, 1000 psi	Elong (2 in.), %
9	15	15	6.0	9.0	25	3.0	4.0	75	1.0	2.5	100
17	24	2	11	17	6	5.0	8.5	14	2.0	5.0	30
21	26	1	7.0	13	8	4.0	8.0	20	2.5	4.5	40
16	21	3	7.0	13	8	4.0	8.0	20	2.5	4.5	40
12	18	9	8.0	13	12	4.0	9.0	17	2.0	5.0	35
9.5	13	12	5.0	7.5	22	3.0	4.5	30	2.0	3.0	50
9.5	13	12	5.0	7.5	22	3.0	4.5	30	2.0	3.0	50
9.5	13	12	5.0	7.5	22	3.0	4.5	30	2.0	3.0	50
9.5	12	10	5.0	7.5	20	2.5	4.0	50	1.5	2.0	80
9.5	12	10	5.0	7.5	20	2.5	4.0	50	1.5	2.0	80
20	25	1	12	18	3	5.0	8.5	10	2.5	5.0	25
21	26	2	7.0	13	10	4.0	8.0	30	2.5	4.5	45
11	17	15	4.0	7.0	25	2.5	3.5	75	1.5	2.5	100
9.5	13	20	5.0	7.5	40	3.0	4.5	50	2.0	3.0	60
9.5	13	20	5.0	7.5	40	3.0	4.5	50	2.0	3.0	60
8.5	10	40	4.5	6.5	50	2.5	4.0	60	1.5	2.0	70
8.5	10	40	4.5	6.5	50	2.5	4.0	60	1.5	2.0	70
15	26	2	9.5	18	5	4.0	10	10	3.0	5.0	15
15	21	18	9.0	13	22	—	—	—	—	—	—
12	16	17	6.0	8.0	23	—	—	—	—	—	—
15	22	7.1	6.0	11	13	—	—	—	—	—	—
13	19	8.0	6.0	10	15	—	—	—	—	—	—
15	23	5.0	8.0	13	10	—	—	—	—	—	—
17	27	3.0	9.0	14	9	—	—	—	—	—	—
12	18	8.0	6.0	9.0	15	—	—	—	—	—	—
13	21	5.0	7.0	12	9	—	—	—	—	—	—

large rake angles, work must be supported firmly to eliminate vibration. Clearance of 8 to 10 deg is necessary between side and front of the tool and the casting being machined. Cutting edges must be sharp and free from burrs, and the tool surfaces must be smooth and scratch-free.

Considerable heat is generated because of the high machining rates. In some cases only a coolant such as a soluble oil is required, but the work should be flooded. Compressed air has been employed successfully to cool the work and remove the chips. If lubrication is required, a proprietary cutting compound can be used.

Recommended practice for machining aluminum alloy castings is given in Table 6. The alloys

TABLE 5—TYPES OF CASTINGS COMPARED
(Ratings: 1 = Best, etc.)

Characteristic ⬇	Sand Castings	Permanent Mold Castings	High Pressure Die Castings
Strength	2	1	2[a]
Structural Density	2	1	3
Reproducibility of Successive Castings	3	2	1
Pressure-Tightness (after machining)	2	1	2
Cost per Piece[b]	3	2	1
Speed of Production[b]	3	2	1
Flexibility as to Alloys	1	2	3
Tolerances	3	2	1
Flexibility of Design	1	2	3
Size Limitation	1	2	3
Surface	3	2	1
Speed of Getting into Production	1	2	2
Pattern or Mold Cost	1	2[c]	3[d]
Thickness of Section	3	2	1

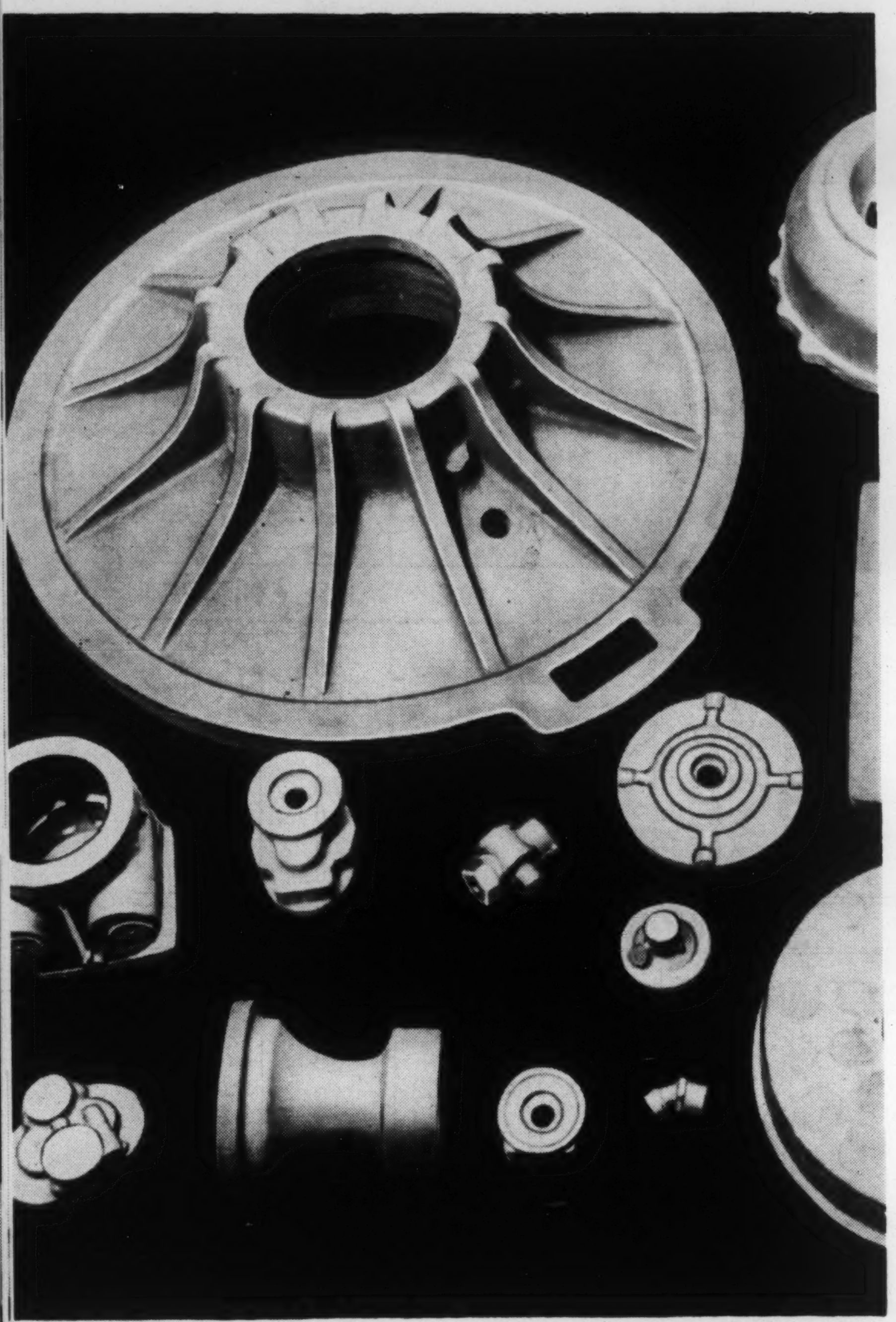
[a] Thin die castings of uniform section may have top rating in the "as cast" condition.

[b] Although this rating covers the majority of castings, in some cases either sand or permanent mold castings may take first place.

[c] The cost of permanent mold equipment may be equal to or less than the cost of production sand casting equipment for large or complicated castings adaptable only to these two processes.

[d] The cost of dies plus the cost of tooling for machining or finishing is frequently less than the same over-all cost for sand or permanent mold castings.

Sand castings are used for . . .

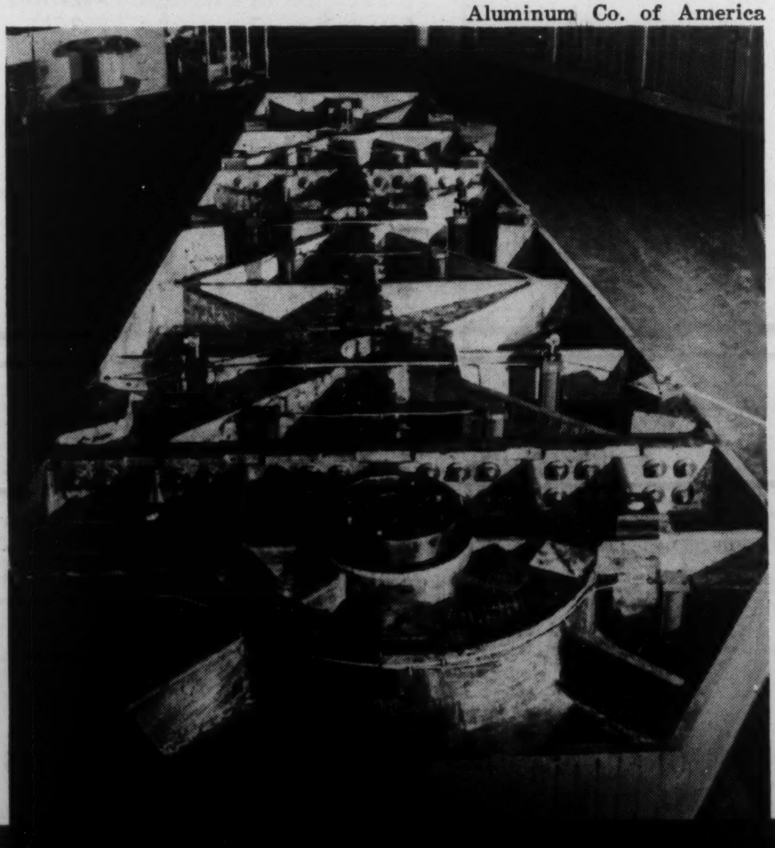


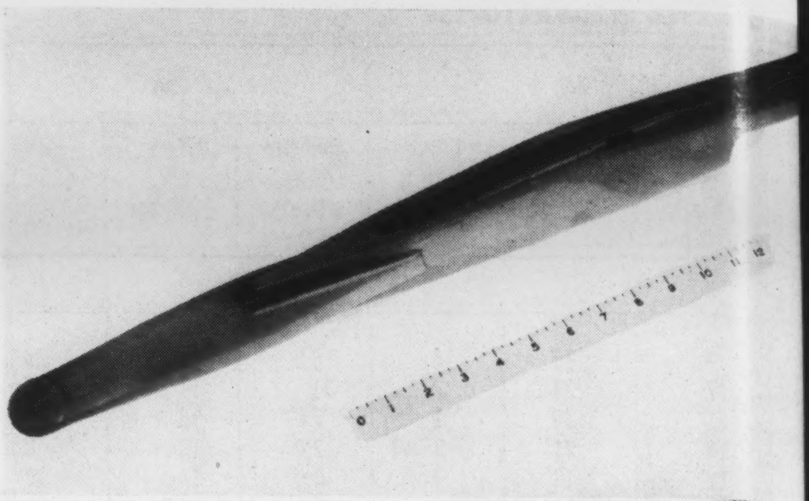
Aluminum Assn.

Fittings—*Fittings and a variety of other small parts are shown here. Sand casting is used frequently for small runs or for simple parts that can be produced in groups.*

Wing fabricating tables—*Assembly of four large sand castings weighs 12½ tons.*

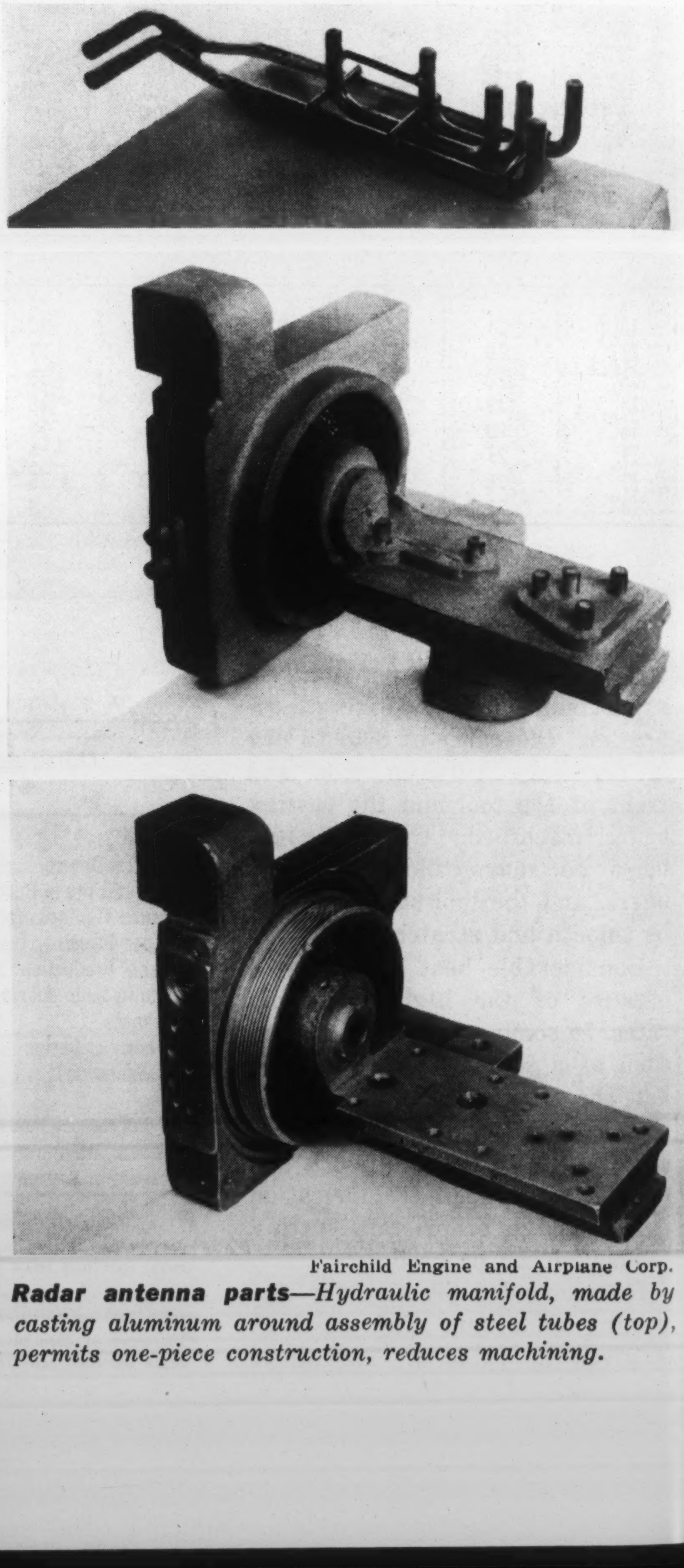
Aluminum Co. of America





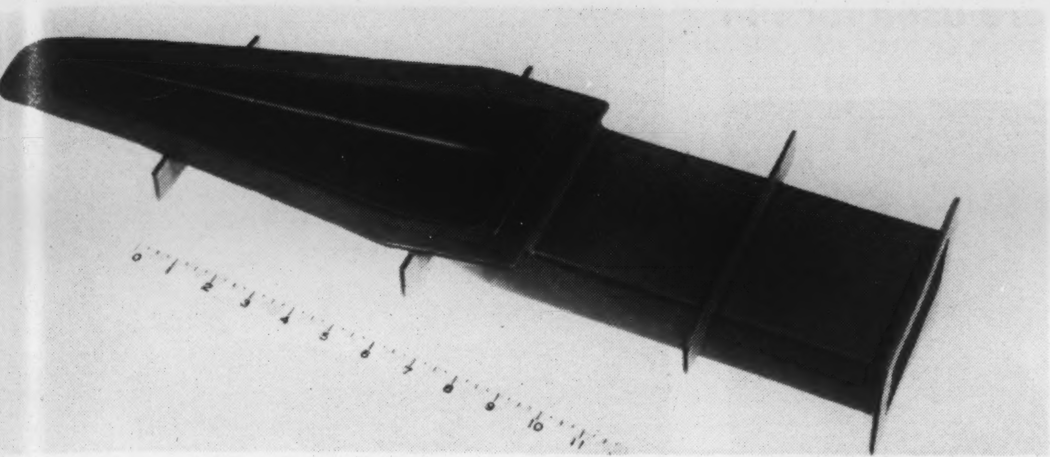
American Brake Shoe Co.

Elevon hinge of missile *(SG70A-T6), cast to close dimensional tolerances to minimize machining, has guaranteed minimum properties of 42,000 psi tensile strength, 35,000 psi yield strength and 3% elongation.*



Fairchild Engine and Airplane Corp.

Radar antenna parts—*Hydraulic manifold, made by casting aluminum around assembly of steel tubes (top), permits one-piece construction, reduces machining.*



American Brake Shoe Co.

Air scoop of missile *was produced from SG70A (later heat treated to T6), by casting in a sand mold using a shell core because of the requirements that the interior surface be 125 rms or better.*

Applications

Aluminum alloy castings are used in a wide variety of applications in the industrial field. Some indication of the uses for specific alloys can be obtained from Tables 9 and 10. Typical applications of sand castings, permanent mold castings, die castings and castings produced by some of the less widely used methods are illustrated on pp 130, 136, 138 and 142.

are graded from A to C depending on their relative machinability, those graded A being the best.

Heat treatment

Addition of some elements to aluminum, e.g., copper, produces alloys that can be altered by heat treatment to enhance the mechanical properties. Based on this characteristic, aluminum alloys can be divided into those that do and those that do not respond to heat treatment. Alloys normally heat treated are C4A, CG100A, CN42A, CS42A, CS66A, G10A, SC51A, SC64B, SC64C, SC82A, SC122A, SG70A and SN122A. Alloys generally aged only are SC103A, ZC60A, ZC81A, ZC81B, ZG32A, ZG42A, ZG61A and ZG61B. Reference to Table 1 will show that some of these are sand castings, others permanent mold castings. Die castings are seldom heat treated.

In aluminum castings, the condition resulting from heat treatment is indicated by a coded designation. Basic designations applicable to heat treatments are:

–T2	Annealed
–T4	Solution heat treated
–T5	Artificially aged
–T6	Solution heat treated and artificially aged
–T7	Solution heat treated and stabilized

Variations from these basic treatments are indicated by additional numbers as explained later.

–T2 (annealed)—Although castings are sometimes annealed to reduce hardness or relieve stresses, most heat treating is employed for other purposes, such as enhancing strength or stabilizing structure. The usual annealing treatment consists of heating the

TABLE 6—RECOMMENDED MACHINING PROCEDURES FOR ALUMINUM CASTING ALLOYS

Operation[a] ↓	Rough Machining			Finish Machining		
	Maximum Cut, in.	Speed, fpm	Feed, in.	Cut, in.	Speed, fpm	Feed, in.
Lathe Turning						
Class A Alloys (not heat treated)	0.25	500 to 900	0.020 to 0.030	0.002 to 0.010	Maximum	0.002 to 0.010
All Other Alloys	0.19	400 to 800	0.007 to 0.020	0.002 to 0.010	600 to 900	0.002 to 0.010
Milling						
Class A Alloys (not heat treated)	0.25	400 to 600[b] 500 to 700[c] Maximum[d]	5 to 15[e]	0.010 to 0.020	500 to 700[b] 500 to 700[c] Maximum[d]	10 to 25[e]
Class A Alloys (heat treated) Class B Alloys	0.25	400 to 600[b] 500 to 700[c] Maximum[d]	40 to 10[e]	0.010 to 0.020	500 to 700[b] 500 to 700[c] Maximum[d]	5 to 15[e]
Class C Alloys	0.25	300 to 500[b]	3 to 8[e]	0.010 to 0.020	500 to 700[b]	4 to 10[e]
Boring						
Light Duty (1-2 in.)	0.09	Maximum[f]	0.010 to 0.020	0.010 to 0.020[a]	Maximum[f]	0.001 to 0.005
Medium to Heavy Duty	0.25	600 to 1000	0.007 to 0.015	0.010 to 0.020[a]	600 to 1000	0.001 to 0.003
Shaping heavy duty—36 in.	0.25	Maximum[g]	0.010 to 0.030	0.005 to 0.010	Maximum[g]	0.100 to 0.150
Planing	0.38	Maximum[h]	0.025 to 0.100	0.005 to 0.015	Maximum[h]	0.050 to 0.375

[a] Class A alloys are GS42A and GZ42A. Class B alloys are C4A, CN42A, CS43A, G4A, SC51A, SC64B and SC64C. Class C alloys are S5A, S12A, S12B, SG70A and SN122A.

[b] For carbon steel tools.

[c] For high speed steel tools.

[d] For cemented carbide tools.

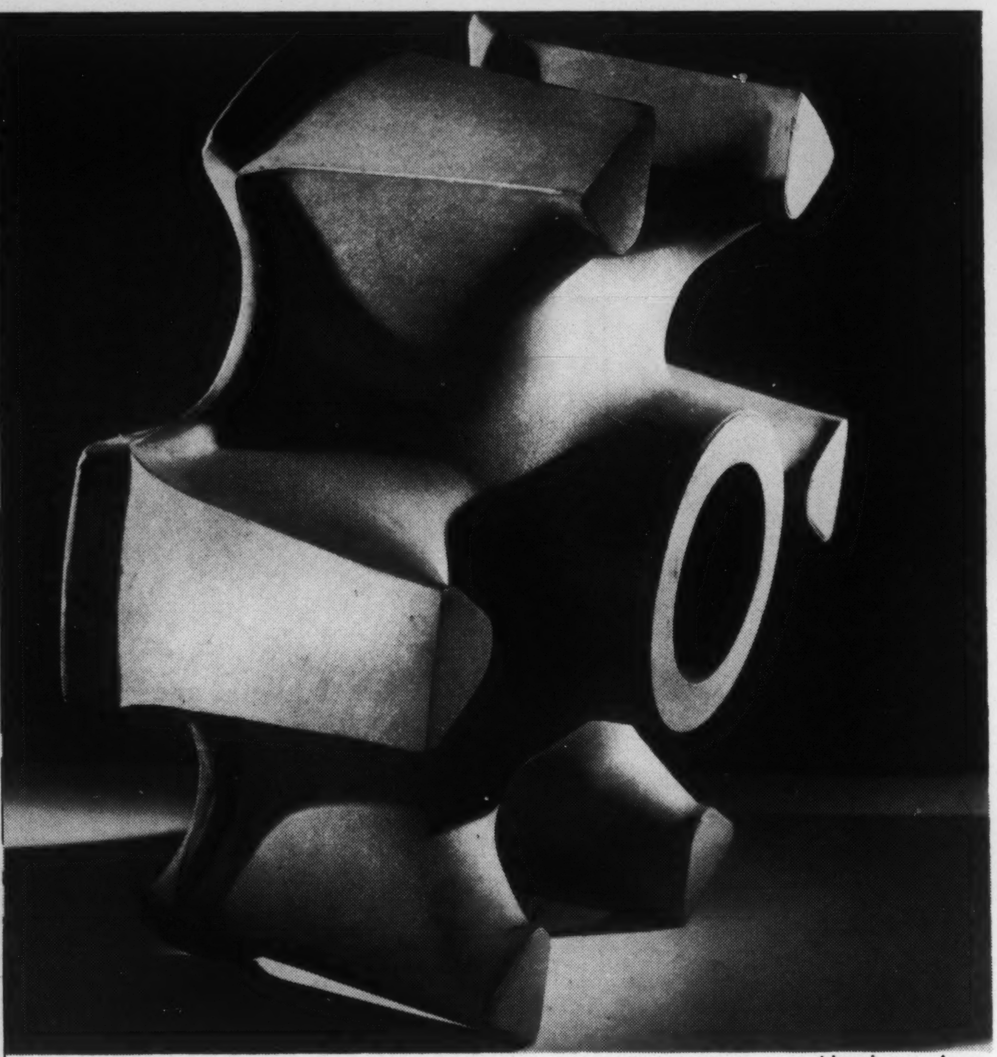
[e] Travel of work.

[f] Peripheral speed of tool is maximum of most machines.

[g] Travel of ram.

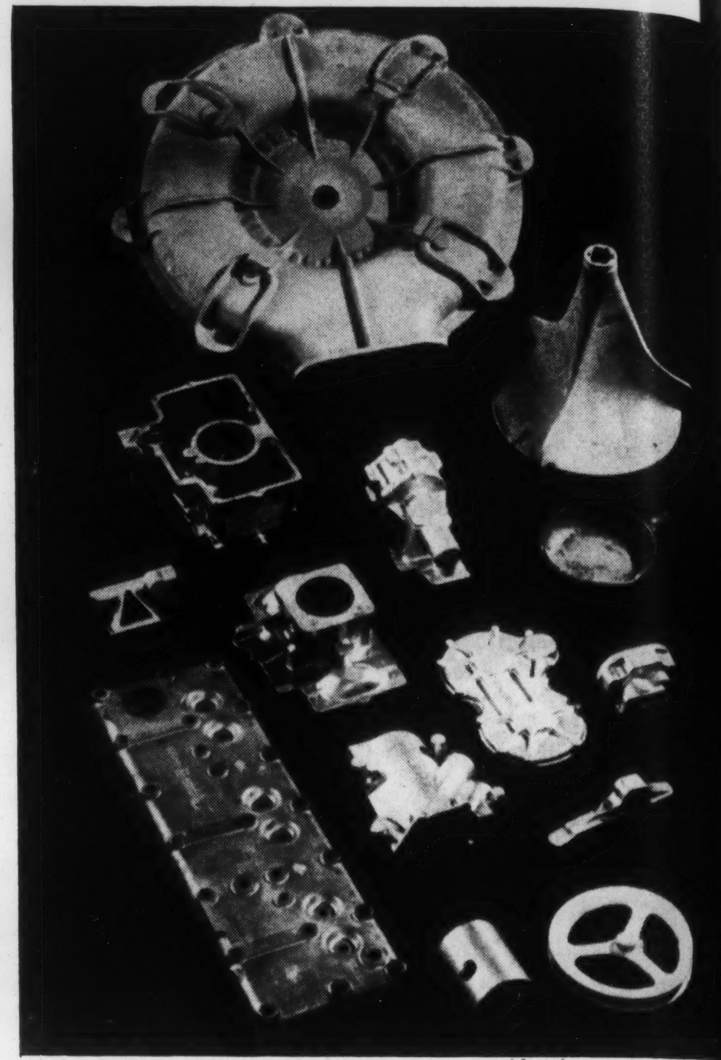
[h] Speed of table.

Permanent mold castings are used for . . .



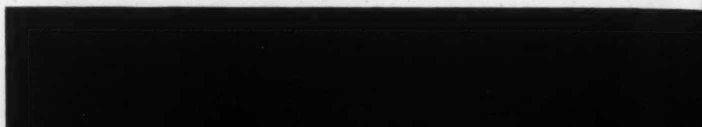
Aluminum Assn.

Truck and bus wheels—*Spoke-type wheels reduce unsprung weight.*



Aluminum Assn.

Automotive and industrial parts—*This group is typical of permanent mold castings.*



Aluminum Assn.

Washing machine agitator—*This type of part is also made by other casting processes.*

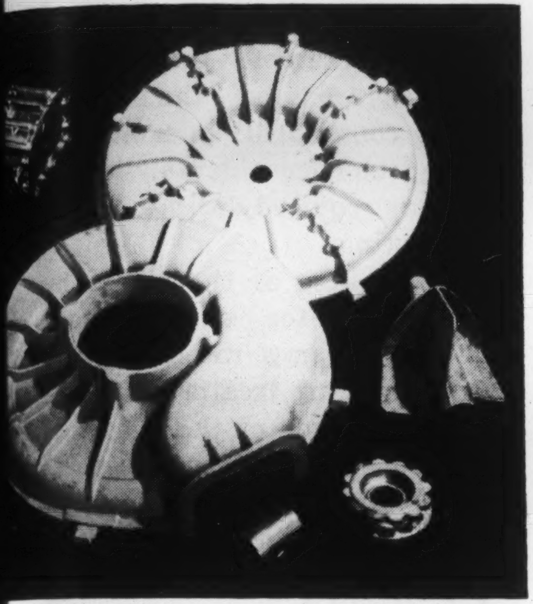
Aluminum Assn.

Timing gears—*This gear is given a stabilizing heat treatment to prevent dimensional changes during service.*

casting to 650 F for about 2 hr and air cooling.

-T4 (solution heat treated)—Solution heat treatment is a thermal treatment in which a suitable alloy casting is heated to a temperature sufficiently high to completely dissolve soluble alloying constituents. As soon as solid solution is completed, the casting is quenched, usually in hot or boiling water. After this treatment the casting is in the T4 condition.

-T5 (artificially aged)—Precipitation of solid constituents from the solid solution causes a considerable increase in strength of the casting. This precipitation can occur at room temperature, but can be hastened by heating at


Aluminum Assn.

***Housings** — Permanent mold castings have closer dimensional tolerances and better pressure tightness than sand castings.*

Aluminum Assn.

***Machine components**—This part is shown with gate and riser still attached.*

TABLE 7—TYPICAL HEAT TREATMENTS

Alloy, Condition ⬇	Solution Heat Treatment			Aging Treatment	
	Temp, F	Time, hr[a]	Quench Medium[b]	Temp, F	Time, hr[c]
SAND CASTINGS					
C4A-T4	960	12	Water	—	—
-T6	960	12	Water	310	3-5
-T62	960	12	Water	310	12-16
CG100A-T61	950	12	Water	310	10-12
CN42A-T21	—	—	—	650	2-4
-T571	—	—	—	340	22-26
-T77	960	6	Still air	650	1-3
SC51A-T51	—	—	—	440	7-9
-T6	980	12	Water	310	3-5
-T61	980	12	Water	310	8-10
-T7	980	12	Water	440	7-9
-T71	980	12	Water	475	4-6
SC64B-T6	940	12	Water	310	2-5
SG70A-T51	—	—	—	440	7-9
-T6	1000	12	Water	310	2-5
-T7	1000	12	Water	440	7-9
-T71	1000	12	Water	475	2-4
PERMANENT MOLD CASTINGS					
CG100A-T52	—	—	—	310	5-7
-T551	—	—	—	340	18-22
-T65	950	8	Water	340	7-9
CN42A-T571	—	—	—	340	22-26
-T61	960	6	Water	400	3-5
CS42A-T4	950	8	Water	—	—
-T6	950	8	Water	310	5-7
-T7	950	8	Water	500	4-6
SC51A-T51	—	—	—	440	7-9
-T6	980	8	Water	310	3-5
-T62	980	8	Water	340	14-18
-T7	980	8	Water	440	7-9
SC64B-T6	940	8	Water	310	2-5
SG70A-T6	1000	8	Water	310	3-5
-T7	1000	8	Water	440	7-9
SN122A-T551	—	—	—	340	14-18
-T65	960	8	Water	340	14-18

[a] Soaking time at temperature for average casting.

[b] Water temperature range 150-212 F. Use of boiling water minimizes residual stresses and distortion.

[c] Select time to obtain desired hardness.

a controlled moderately elevated temperature. If the latter method is employed the treatment is called artificial aging and the resulting condition is known as T5.

–T6 (solution heat treated and artificially aged)—Since artificial aging can be applied directly to the material in the as-cast condition, an additional designation is necessary to indicate those castings that have received the complete cycle of solution treatment followed by artificial aging. This condition is designated T6.

–T7 (solution heat treated and stabilized)—In any heat treatable alloy, elements held in solid solution, either as the result of a solution heat treatment or of rapid cooling during casting, can precipitate gradually over a long period of time and cause growth of the casting. This growth, a permanent dimensional increase, is particularly pronounced in castings that are used in elevated temperature applications. A combination of solution heat treatment and a long aging treatment at a suitable temperature causes most of the potential dimensional increase to occur, permitting the casting to be machined to size after stabilization has taken place. The condition resulting from this treatment is designated T7.

Typical heat treatments for a number of sand and permanent mold casting alloys are given in Table 7. Modification of the basic treatment is indicated by additional figures in the condition symbol. For example, the table shows the temperature and time for solution treatment and aging of C4A sand castings to produce the T6 condition. Modification of the aging time produces the condition designated as T61.

TABLE 8—RELATIVE EASE OF JOINING[a]

Alloy	Welding			Brazing	Soldering	
	Gas	Arc	Resistance		Flow	Friction
SAND CASTING ALLOYS						
C4A	C	B	B	X	D	A
CG100A	C	B	B	X	X	A
CN42A	C	B	B	X	D	A
CS43A	B	D	B	X	D	A
G4A	B	A	B	X	B	A
G10A	D	C	B	X	B	A
S5A	A	A	A	B	B	A
SC51A	A	A	A	X	C	A
SG70A	A	A	A	X	B	A
PERMANENT MOLD CASTING ALLOYS						
CG100A	D	C	B	X	X	A
CN42A	C	B	B	X	D	A
CS42A	C	B	B	X	D	A
CZ42A	B	A	B	X	B	A
S5B	A	A	A	B	B	A
SC51A	A	A	A	X	C	A
SC64A	A	A	A	X	D	A
SG70A	A	A	A	X	B	A
DIE CASTING ALLOYS						
G8A	D	D	D	X	B	A
S5C	B	B	C	A	D	A
S12A	D	D	D	X	C	A
SC54A	D	D	D	X	D	A
SC84A	D	D	D	X	D	A
SG100B	D	D	D	X	B	A

[a] Relative rating of alloys for each joining method: A = excellent, B = good, C = fair, D = poor, X = not recommended.

A few general comments on the heat treating conditions are necessary:

1. The furnace used should be capable of holding temperatures within ±5 F to obtain satisfactory results.

2. The soaking time is that suggested for an average casting. Depending on the particular casting and also on the casting method, this time may vary considerably. For example, the time to completely dissolve the soluble alloying constituents in sand castings is usually considerably longer than that required for permanent mold castings.

3. Regardless of the alloy, the temperatures for solution heat treatment lie in a rather narrow range. In aging treatments, however, composition of the alloy has a pronounced effect on the temperature required for optimum results. An aging temperature satisfactory for one alloy can be sufficiently high to over-age and soften another alloy.

4. Time required for artificial aging also varies widely, being determined not only by the composition but also by the shape of the casting. The figures given in the table are only suggestions. Time schedules should be set to produce hardness values that are typical for the material in the specified condition.

5. Die castings solidify so rapidly that they are practically quenched when removed from the die. When close machining tolerances are required, however, die castings may be stress relieved by heating to the range 350 to 500 F for 4 to 6 hr and cooling in still air. Another treatment is sometimes used to increase ductility; this consists in heating the casting to the 500 to 700 F range for 4 to 6 hr and cooling in the furnace or in still air.

Joining

Welding—Broken castings and foundry defects in aluminum castings can often be repaired by welding. Areas to be repaired must be cleared of unsound metal and dross and thoroughly cleaned. Depending on the size of the casting, it may be necessary to preheat the part at a temperature of about 800 F to avoid thermal stresses. After welding, slow cooling is advisable to prevent cracking.

Castings not requiring heat treatment can be welded with rods of S5A or SC64A. Heat treatable castings should be welded with rods of the same alloy, and they should either be welded before heat treatment or re-heat treated after the joint has been made.

Best results are obtained with the inert gas welding methods. Torch welding can also be used. In addition to these methods, resistance welding is used in assembly.

Brazing — Aluminum castings can also be brazed using standard methods. Torch, furnace or salt bath brazing is preferred. Brazing fluxes, usually of a proprietary nature, are essential.

Filler metals are aluminum-base alloys, and brazing temperatures are quite close to the melting point of the casting alloys. Not all aluminum alloys can be brazed, since it has not been possible to develop suitable filler metals with sufficiently low melting points.

Torch brazing requires a high degree of skill to prevent melting the base metal. Furnace and salt bath brazing require close temperature control for the same reason. In salt bath brazing, a suitable molten flux replaces the usual mixed salts, serving not only to heat the part to the brazing temperature but also to remove the oxide coating.

Soldering — Soldering is not widely used in joining aluminum castings because special procedures have always been required. Either friction soldering, in which the surface is abraded under a flux cover to remove the oxide skin, or flow soldering, in which the oxide coating is dissolved by a suitable flux, can be used. Development of a new technique using a zinc alloy is expected to increase applications.

The relative ease of joining aluminum alloy castings is indicated in Table 8.

Cleaning and finishing

Castings can be cleaned by grinding, filing, surface blasting or chemical methods. Grinding wheels suitable for aluminum alloy castings often employ aluminum oxide abrasives, although other abrasives can be used. Files are used to clean areas that cannot be reached by wheels. Blast cleaning, employing sand, steel grit or shot, is widely used for cleaning and leaves the surface with an attractive matte finish that frequently requires no additional treatment. Wire cores in intricate castings can be removed by immersion of the casting in an acid bath.

If finer finishes are required, mechanical, chemical or electrochemical finishing methods can be used.

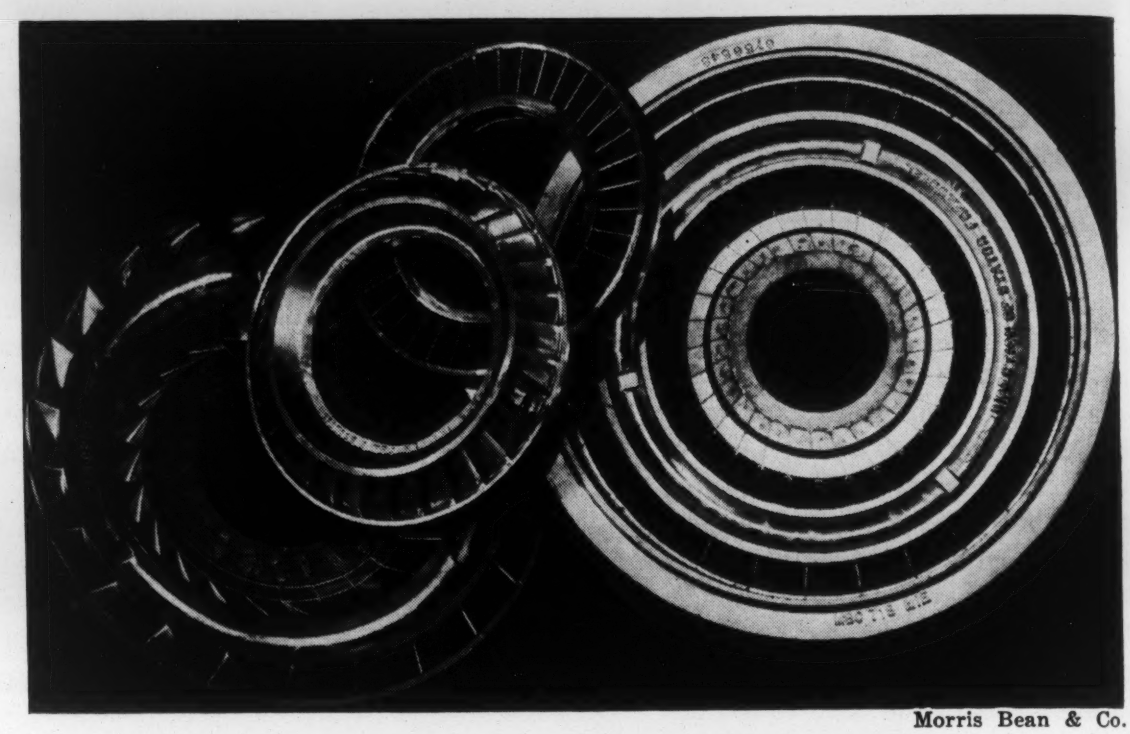
Polishing and buffing are the oldest, and probably the most

TABLE 9—ALUMINUM CASTING ALLOYS CLASSIFIED BY TYPE OF APPLICATION

Application ⬇ / Type of Casting ➡	Sand	Permanent Mold	Die
General Purpose	C4A CS43A SC64B SC64C ZG61A	CS42A SC64B SC64C	S12A SC84B SG100A
General Purpose Where Pressure Tightness Required	CS72A S5A SC51A SG70A	CS72A S5A SC64A SC51A SG70A	SC84B SG100A
Architectural and Decorative	S5A G4A GS42A SG70A ZC81A ZG32A GZ42A ZG61A ZG61B	S5A GS42A GZ42A SG70A ZC60A ZC81B ZG32A ZG42A	G8A S12A SG100A
Corrosion Resistance	S5A S5B G4A G10A GS42A SG70A ZC81A ZG32A ZG42A ZG61A ZG61B	S5A S5B GZ42A SG70A ZC81B ZG32A ZG42A	G8A S5C S12A SG100A
Retention of Strength at Elevated Temperatures	CG100A CN42A SC51A SC82A	CG100A CN42A SN122A SC51A SC122A	SC84A[a] SC84B[a] SG100A[a]
Pistons	CG100A CN42A	CG100A CN42A CS66A SN122A SC122A	SC84B

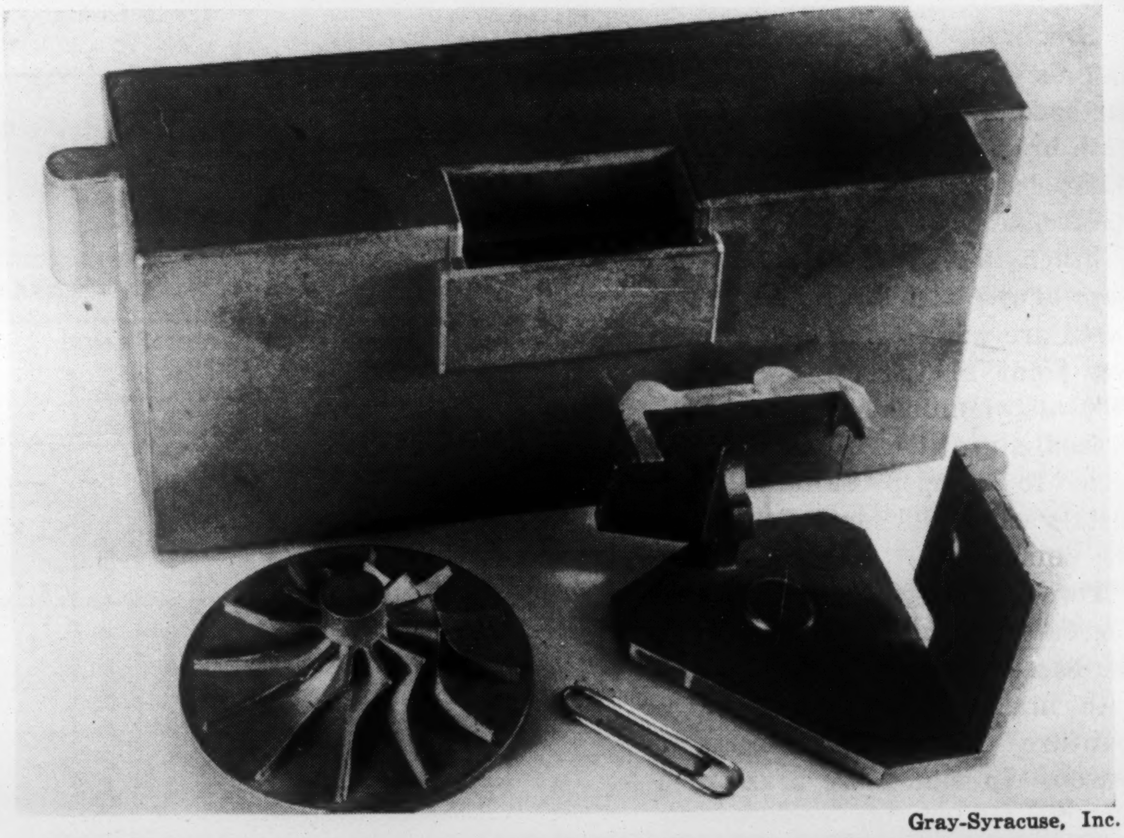
[a] When service temperatures are above 600 F, die castings may develop surface blisters.

Investment, vacuum and plaster mold castings are used for . . .



Torque converter parts—*This set of heavy duty elements, made by plaster mold casting, is required to meet exacting performance requirements. Vane thickness, passageways and diameters are held to ±0.015 in.*

Morris Bean & Co.



Impellers, housings and brackets—*These parts are investment cast to close tolerances and must be radiographically sound.*

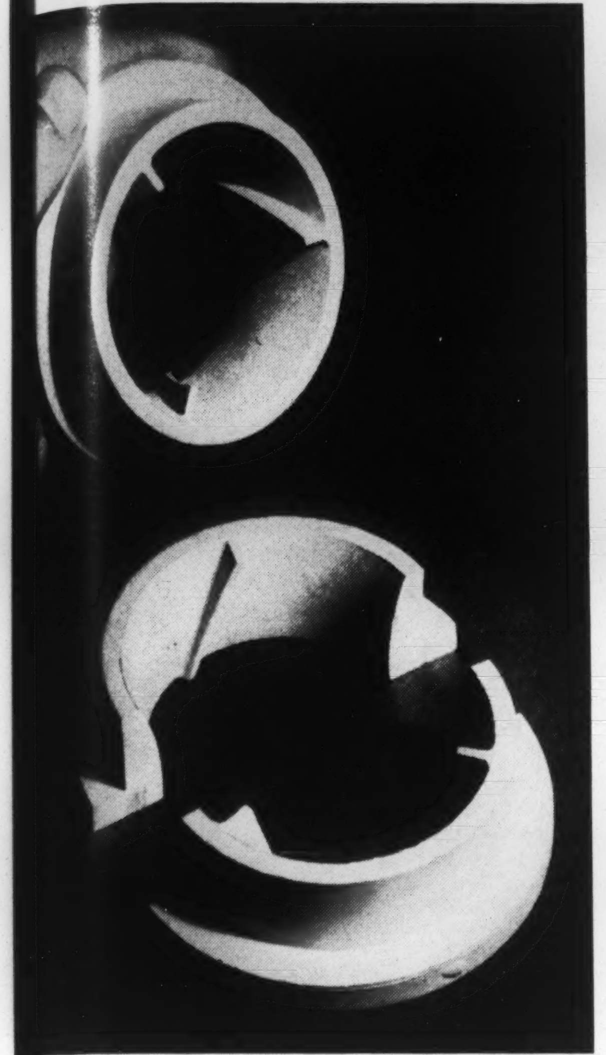
Gray-Syracuse, Inc.

Missile fin—*This fin, a plaster mold casting, meets aerodynamic requirements, including tolerances of ±0.010 in. on thickness and ±0.020 TIR on flatness, and a surface smoothness of 125 rms or better without machining.*

Morris Bean & Co.

widely used, procedures for mechanical finishing. Fine polishing with emery dust is performed on a wheel that is lubricated with beeswax, tallow or oil to prevent burning. Following this treatment, the finish may be refined by buffing. Buffing involves working an abrasive, carried in grease, into the surface being finished. Final polishing, to produce a high gloss, is done by using a flannel or muslin wheel and a grease compound containing silica dust.

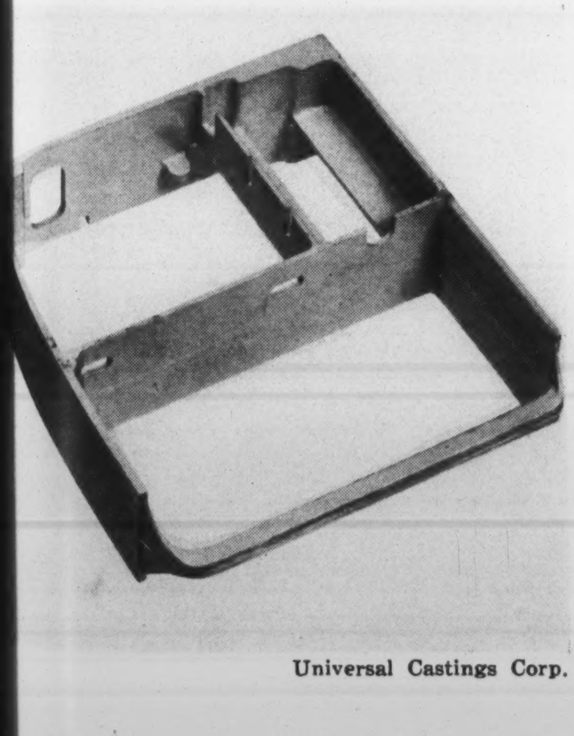
Chemical finishes are produced by immersing the casting into a suitable solution in which the desired reaction occurs. These finishes are decorative and corrosion resistant but not very durable. Typical procedure is to immerse the casting into an alkali, rinse



Precision Metalsmiths

***Pump diffuser ring**—This investment cast fuel pump diffuser ring must be held to close tolerances and have an internal surface finish of 90 rms or better.*

***Aircraft instrument frames**—This airborne instrument frame is vacuum cast from SG70A for high strength and rigidity. Assembly previously used was not sufficiently rigid to prevent binding of moving parts.*



Universal Castings Corp.

TABLE 10—MAJOR CHARACTERISTICS AND USES

Alloy ↓	Outstanding Characteristics	Typical Uses
SAND CASTINGS		
C4A	Fair casting characteristics; good machining properties; good combination of mechanical properties	Crankcases, bus wheels, housings, spring hangers, fittings
CG100A	Good strength at elevated temperatures; good wear resistance	Cylinder heads, bearings, bearing caps, bushings, tappet guides
CN42A	Good strength at elevated temperatures	Cylinder heads, diesel engine pistons
CS43A	Better casting properties and pressure tightness than aluminum-copper alloys	Manifolds, valve bodies, pressure-tight castings
CS72A	Good pressure tightness	Castings requiring pressure tightness
G4A	Excellent resistance to corrosion and tarnish	Dairy and food handling equipment, cooking utensils, chemical fittings, hardware
G10A	Highest strength and elongation of aluminum sand casting alloys; excellent machinability; resistance to corrosion	Aircraft fittings, levers, brackets, castings requiring shock resistance
GS42A	Excellent resistance to corrosion	Pipe fittings for marine and general use, cooking utensils
S5A	Excellent casting properties; pressure tightness; good weldability; good corrosion properties	Marine fittings, food handling equipment, pipe fittings
SC51A	Good casting properties; pressure tightness; very good weldability	Cylinder heads, water jackets, housings, printing press bed plates
SC64B	Excellent casting properties; good mechanical properties	Crankcases, oil pans, housings, general purpose castings
SG70A	Excellent casting properties; excellent weldability; good corrosion resistance	Automotive transmission cases, housings, aircraft fittings
ZG61B	High strength and ductility without heat treatment; good machinability	General purpose castings
PERMANENT MOLD CASTINGS		
CG100A	Retention of strength at elevated temperatures; good hardness, machinability and wear resistance	Meter parts, automotive pistons, bushings, bearings
CS42A	Good castability and machinability; good welding properties	Aircraft fittings, fuel pump bodies, gear housings, seat frames

(table continued on next page)

and immerse in an acid. There are also a number of proprietary immersion coatings that are generally used to prepare a surface suitable for painting.

Electrochemical finishes are produced by making the casting the anode in a suitable electrolytic bath (anodizing). An oxide coating is formed that can be transparent, translucent or opaque depending on conditions of formation. Colored coatings can also be produced by using suitable dyes.

TABLE 10—MAJOR CHARACTERISTICS AND USES—continued

Alloy ⬇	Outstanding Characteristics	Typical Uses
PERMANENT MOLD CASTINGS—continued		
CS66A	Good casting properties and machinability	Pistons
CS104A	Good casting properties; high hardness as cast	Sole plates for electric irons
GS42A	Excellent resistance to corrosion	Pipe fittings for marine and general use, cooking utensils
GZ42A	Good resistance to corrosion and tarnish	Cooking utensils
S5A	Excellent casting properties; pressure tightness; good corrosion resistance	Refrigerator fittings, carburetor bodies, thin-section general purpose castings
SC51A	Good castability and pressure tightness; very good weldability	Aircraft supercharger impellers, timing gears, meter parts, rotors
SC64A	Good castability with pressure tightness; good weldability	Castings requiring pressure tightness
SC64B	Excellent castability; good mechanical properties	Engine parts, cylinder heads, typewriter frames
SN122A	Good properties at 500 to 600 F; low coefficient of thermal expansion	Automotive and diesel pistons, sheaves, pulleys
ZC60A	High strength and ductility without heat treatment	Parts requiring assembly by brazing, impeller blades
DIE CASTINGS		
G8A	Excellent resistance to corrosion and tarnish; excellent strength and ductility	Aircraft fittings and brake shoes, marine fittings, hardware
S5C	Very good resistance to corrosion; good weldability	General purpose castings
S12A	Good corrosion resistance; good mechanical properties	Dental equipment, outboard motor pistons, typewriter frames
SC84A	Good castability; good mechanical properties (impurity limits lower than SC84B)	General purpose castings
SC84B	Good castability; good mechanical properties	General purpose castings
SC100A	Excellent castability; good mechanical properties; good corrosion resistance (impurity limits lower than SC100B)	General purpose castings requiring greater ductility than SG100B
SG100B	Excellent castability; good mechanical properties; good corrosion resistance	General purpose castings, instrument cases, cover plates

Aluminum castings can be electroplated with other metals, usually over a base coat of zinc applied by a chemical immersion process. Coatings of silver, nickel, gold and copper have been used, usually for decorative effects, although silver can be used to improve surface electrical conductivity.

Decorative effects are also obtained by painting, enameling or lacquering. Suitable surface preparation is essential to assure adherence. This preparation may be a mechanical finish, an anodized finish, a priming coat of zinc chromate or an aluminum paint.

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Castings Corp.
Dollin Corp.
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FILE FACTS

Metallic Coatings for Corrosion Prevention[a]

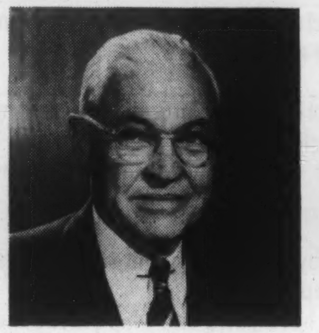
Coating Metal	Method of Application	Protective Uses
Aluminum	Hot Dipping	Steel wire and sheet, heat exchangers, fittings, structural parts, dissimilar metals in contact with aluminum, and elevated temperature applications
	Evaporation (vacuum metallizing)	Coatings for mirrors and various nonmetallic materials. Slow process by vacuum evaporation (normal flashing period gives 0.005-mil coating)
	Electrodeposition	Same as for hot dipping, but is especially useful where temperature of molten aluminum or brittle diffusion zone is harmful
	Vapor Plating (halide decomposition)	Where thickness required exceeds that obtainable by hot dipping and where parts can be heated to 1850 to 2100 F while coating is applied
	Spraying	Where thickness required exceeds that obtainable by hot dipping and where moderate adherence is required
Cadmium	Electrodeposition	Coatings 0.3 to 1 mil thick are used on iron and steel where zinc is less suitable, as in 80 to 100% relative humidity. Used particularly for precision instruments and as undercoat for zinc on cast and malleable iron; also copper and copper alloys in contact with iron and steel. Good solderability with noncorrosive fluxes
Cadmium-Tin Alloy	Electrodeposition	Iron and steel parts in contact with oils. Better throwing power than cadmium or zinc on irregular shapes
Chromium	Electrodeposition	"Crack-free" coatings of about 0.3-1 mil provide good protection on ferrous and nonferrous metals; 0.01-mil coating prevents tarnishing of nickel plate and imparts scratch resistance. Special fixturing may be needed to cover recessed areas
	Evaporation	Where a thin overlay (0.005 mil) is required
	Chemical (electroless)	Needs further development; has good prospects as a coating for iron, steel and nonferrous alloys. Coating structure is unlike electrodeposited structure
	Vapor Plating	Limited application; provides good wear, heat and corrosion resistance with fair ductility on parts that can be heated to 1850 to 2100 F while coating is applied. Coatings of 0.5-1 mil used for outdoor applications
Cobalt	Electrodeposition	Use is relatively unexplored; should be comparable with nickel for steel, iron and nonferrous metals
Copper	Electrodeposition	Envelope protection for iron and steel in thicknesses of 1 mil or more. May need nickel, nickel and chromium, or tin overlay for resistance to tarnishing and formation of green patina
	Chemical Displacement	Temporary protection and iron and steel surfaces subject to mild exposure. Coatings of less than 0.005 mil. Can be immersion coated with tin
Copper-Tin Alloy (bronze)	Electrodeposition	Excellent for protecting iron and steel; equal to or better than nickel in salt spray resistance and in temperate and semitropic climates. Coatings of 1-10 mils have good antigalling and bearing properties. May need tin or nickel overlay for special purposes
Copper-Zinc Alloy (brass)	Electrodeposition	Iron and steel surfaces subject to mild exposure. Yellow brass not as good as zinc, cadmium, tin-zinc, cadmium-tin or nickel. Used to aid adhesion of rubber on steel. White brass has some merit for inside use, but is brittle
Gold	Electrodeposition	Electronic and electrical components where nontarnishing and good conductivity are needed. Can only give envelope protection to common basis metals. Also used for heat reflection
	Evaporation	Coatings of less than 0.005 mil used to prevent tarnishing
Indium	Electrodeposition	Bearing overlay to prevent hot oil erosion. More costly than other coatings used to protect metals in atmospheric exposure. Might replace tin in time of tin shortage
Iron	Electrodeposition	Not for corrosion protection of other metals
Iron-Zinc Alloy	Electrodeposition	Iron and steel. Coating can be deformed without damage. Equal to or better than zinc in corrosion protection; less reactive than zinc in contact with paint films. Coating easily soldered

(continued on p 149)

◄ For more information, circle No. 523

RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY



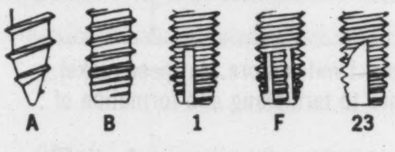
Technical-ities

By John S. Davey

How to select tapping screws

1. Use *thread forming* screw Type A, B or C when material is ductile enough to stand deforming action of screw. If not, use *thread cutting* type.

2. Type A is used with pierced hole for starting; and where an exposed point doesn't matter. All other cases use B, C, or other blunt screws in drilled holes.



3. When load is no factor, metal gauge determines diameter of screw. Pick a thread pitch which gives at least a full thread engagement.

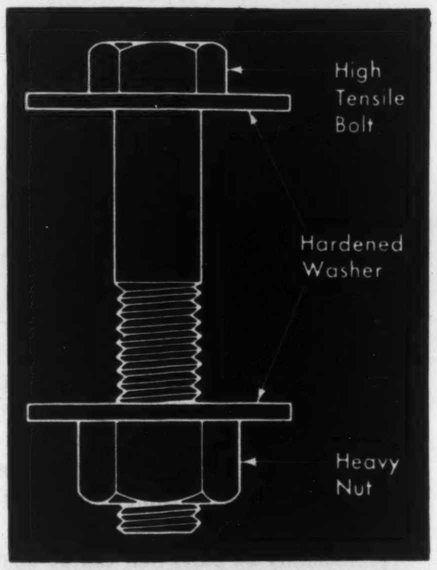
FOR EXAMPLE: Metal .062" thick suggests use of #7 Type A or #10 Type B (both have 16 threads/inch).

$$\text{PITCH}=\frac{1.00}{16}=.0625''$$

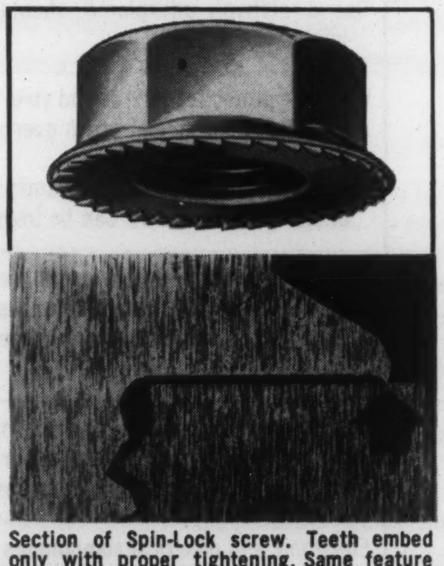
4. When you do have loads to sustain, you must consider required holding power. If metal thickness doesn't allow ample thread engagement (so that threads strip), use more smaller diameter screws. They engage more threads. Limiting factors: the screw's torsional strength, and the effort to drive it.

5. If, due to material thickness, screws fail by torsion or drive too hard, select cutting screws (1, F, or 23). For hard ductile materials, the Type 1 is best; for soft, friable materials, the Type 23.

Two basic ways to keep fasteners tight



RB&W high strength bolts permit optimum tightening without crushing surface when used with hardened washer.



Section of Spin-Lock screw. Teeth embed only with proper tightening. Same feature available in nuts.

Fasteners that stay tight keep joints strong. Resistance to loosening depends largely upon: (1) The inherent "locking" ability, (2) The man with the wrench.

HIGH PRELOADING

With rigid type joints, one of the best "locking" fasteners is a standard RB&W high strength bolt or cap screw . . . *torqued up close to its yield strength.* It locks by its own internal residual tension.

High tension not only keeps it permanently tight, but also prevents fatigue, assures optimum load capacity and safety.

INTEGRAL LOCKING DEVICE

Suppose the design of fastened members can't take full advantage of such preloading? Then a lock is needed, such as that furnished by RB&W Spin-Lock® screws and nuts. Ratchet-action teeth bite into seat; require 20% extra torque to loosen.

Note that Spin-Lock fasteners seat solidly before locking. The installer can't be deceived. He *has* to tighten properly before feeling resistance.

In both cases above, *positive* tightening assures positive fastening.

Send for Bulletin on Spin-Lock fasteners, or call your local RB&W Fastener Man. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Staked acorn nuts lock securely

Staking opposite sides of these RB&W acorn nuts deforms threads for a positive grip. It also puts middle of nut slightly out-of-round, for a spring tension locking effect. They're designed for applications such as outdoor furniture, where anchoring fasteners is more important than solid seating. Available in aluminum, steel, silicon bronze.

These all-metal nuts can also be furnished in regular double chamfered style. Since they lock with their middle threads, they can be turned onto screw from *either* side.

For more information, turn to Reader Service card, circle No. 377

Metallic Coatings for Corrosion Prevention[a]—continued

Coating Metal	Method of Application	Protective Uses
Lead	Electrodeposition	Ferrous and nonferrous metals needing protection from acids, hot corrosive gases and ambient atmospheric conditions. May cause stress corrosion cracking at temperatures near or above melting point of lead
	Chemical Displacement	Iron and steel where thin coatings (0.005 mil) are satisfactory
	Evaporation	Fast deposition—as high as 3 mil in 10-15 min
Lead-Tin Alloy	Electrodeposition	Harder and more protective than lead and used in same applications. Protects from corrosion and has good antifriction and bearing properties for heavy duty bearings
	Hot Dipping	Ferrous parts in same applications as lead coatings. Control over coating thickness is limited
Lead-Indium Alloy	Electrodeposition Plus Heat Diffusion	Similar to lead-tin
Molybdenum	Vapor Plating	Not used commercially. Can be applied up to 5 mil or more. Applied at 1700-1850 F
	Fused Salt Electrolysis	Still in laboratory stage
Nickel	Electrodeposition	Ferrous metals to protect by envelope action; nonferrous metals to prevent tarnishing. Coatings vary from 0.3 to 2 mil. Nickel tarnishes mildly and can be protected by 0.01-mil chromium coating
	Chemical (electroless)	Ferrous and some nonferrous parts not amenable to electroplating, e.g., inaccessible inside surfaces. Coating is hard and stable and contains 5 to 8% phosphorus
Nickel-Tin Alloy	Electrodeposition	Ferrous and nonferrous parts. Superior to nickel in some environments. Coatings are hard and brittle but more tarnish resistant than nickel. Both have excellent throwing power
Platinum	Electrodeposition	To preserve surfaces subject to unusually corrosive environments
Rhodium	Electrolysis	To prevent other metals such as silver and nickel from tarnishing. Coatings are usually less than 0.1 mil, but can be applied up to 2 mil. Cost is comparatively high and chromium may do as well for some applications
Silicon	Vapor Phase	Where extreme chemical resistance is required; resists oxidation at high temperatures. Applied at 1700-1850 F
Tantalum	Vapor Phase	Same as silicon
Tin	Electrodeposition	Ferrous and nonferrous surfaces to be in contact with foods, to be soldered, or to be used as bearings; provides excellent resistance to tarnishing and rusting
	Hot Dipping	Ferrous and nonferrous surfaces to be in contact with foods; prevents rusting and tarnishing. Thickness control limited but coating covers crevices, seams and corners better than electrodeposits. Sometimes used under tin electrodeposits
	Chemical Immersion	To prevent tarnishing of copper, brass and bronze
Tin-Zinc	Electrodeposition	Ferrous and nonferrous surfaces. Has less bulky corrosion products than zinc coatings. Superior to cadmium in some atmospheres; easy to solder and paint
Titanium	Fused Salt Electrolysis	Still in laboratory stage
Zinc	Electrodeposition	Iron and steel wire, structural and machine parts, packaging cans and instrument chassis where bulky corrosion products do not form or are not detrimental. Has broad thickness range. Deposits are highly stressed; hard steel parts may be subjected to hydrogen embrittlement
	Hot Dipping	Same general uses as electrodeposited coatings. Limited to parts capable of withstanding molten zinc and brittle diffusion layer. No hydrogen embrittlement. Coating thickness uncertain and limited to narrow range
	Spraying	Thicker coatings than electrodeposited or hot dipped, but more susceptible to porosity; inferior bonding. Difficult to coat recessed areas

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[a] Coatings applied by electrodeposition, hot dipping and vapor plating (vapor phase, halide decomposition) usually range from 0.2 to 2 mil; coatings applied by evaporation (vacuum metallizing) are usually less than 0.1 mil thick.

Prepared by Charles L. Faust and William H. Safranek, Battelle Memorial Institute, and presented at the NAVCERLAB Symposium on Preservation for Mobilization Requirements, October, 1956.

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Errata — *Materials Selector* Issue

Mid-September, 1957—Vol. 46, No. 4

On this and the following page are listed corrections for the Data and Directory Sections of the *Materials Selector* Issue. We suggest you make the corrections directly in your *Selector* or attach the entire errata sheet inside the front or back cover of the issue. The errors in the Data Section, listed below, are identified by page, column and line number. The additions to the Directory Section, given on the following page, are identified by page and column number, and by the material classification under which they belong.

DATA SECTION

P 5, col 1, "G," l 2—change to:
Gilding (see also Brass), 86

P 6, col 1, "R," l 1—change to:
Radiation effects, 28

P 8, col 1, l 42—change to:
Wrought and Nodular Irons ...7.17...0.25

P 8, col 1, l 53—change to:
Molybdenum ....10.2...—

P 8, col 1, l 55—change to:
Allyls (cast) ....1.38...0.08

P 8, col 1, l 58—change to:
Uranium ....19.1...—

P 8, col 1, l 62—change to:
Magnesium Alloys ....1.81...0.04

P 8, col 2, l 1—change to:
Polystyrenes, GP ....1.06...0.02

P 8, col 2, l 28—change to:
Borosilicate Glass ....2.28...0.15

P 8, col 2, l 48—change to:
Fused Silica Glass ....2.19...—

P 8, col 2, l 50—change to:
96% Silica Glass ....2.16...—

P 8, col 2, l 52—change to:
Aluminum Silicate Glass .....2.52...—

P 8, col 2, l 53—change to:
Soda-Lime Glass ....2.49...—

P 8, col 2, l 55—change to:
Lead Silicate Glass ....3.57...0.69

P 8, col 2, l 64—change to:
Mod Polystyrenes, Ht & Cml
Res ....1.08...0.03

P 9, col 1, l 1—change to:
Cobalt ....39.9...—

P 9, col 1, l 8—change to:
Soft Leads ....19.5...0.2

P 9, col 1, l 13—change to:
Natural Rubber ....0.082...—
Silicone Rubber ....0.177...0.017

P 9, col 1, l 16—change to:
Inconel[b] ....8.7...—

P 9, col 1, l 45—change to:
Tantalum Carbide[b] ....12.8...—

P 9, col 2, l 63—delete:
Ceramic Fiber line

P 12, col 1, l 49—change to:
96% Silica Glass[b] ....$>10^{21}$

P 12, col 2, l 5—change to:
Silicone Plastics ....$>3.4 \times 10^{13}$

P 12, col 2, l 13—change to:
Gray Irons 50-200

P 13, col 1, l 2—delete:
Magnesium Alloys line

P 13, col 1, l 6—change to:
Rhodium ....420...—

P 13, col 2, l 8—change to:
Iridium ....740...—

P 14, col 1, l 31—delete:
Aluminum Silicate Glass line

P 14, col 1, l 32—change to:
High Carbon Steels (HR) .....125...—

P 14, col 1, l 34—change from Sheet Felts to: Bast Fibers

P 14, col 1, l 43—change from Roll Felts to: Hard Fibers

P 14, col 2, l 51—change from Roll Felts to: Animal Fibers

P 16, col 1, l 18—change to:
Nylon[b] ....300...—

P 16, col 1, l 24—change to:
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P 16, col 1, l 30—change to:
Ingot Iron, CD ....12...—

P 16, col 1, l 56—change to:
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P 16, col 2, l 2—change to:
Nickel Silvers, Ann. ....45...13

P 16, col 2, l 13—change from Ingot Iron, Ann. to: Low Carbon Steel (HR)

P 16, col 2, l 21—change to:
Carbon Steel (cast), Ann. ....26...6.

P 16, col 2, l 22—change from Bast Fiber to: Animal Fibers

P 16, col 2, l 43—change to:
Wrought Iron (HR) ....35...—

P 16, col 2, l 49—change to:
Ingot Iron (HR) ....47...—

P 17, col 1, l 42—change to:
Zinc Alloys (CR) ....27...17

P 17, col 2, l 19—change from Sheet Felts to: Bast Fibers

P 17, col 2, l 38—change from Roll Felts to: Hard Fibers

P 17, col 2, l 55—delete Inconel, Age H line

P 18, col 1, l 33—change to:
Duranickel, Age H ....C35...5

P 18, col 1, l 43—change to:
Monel, Age H ....C29...5

P 18, col 2, l 67—change to:
Wrought Iron (HR) ....105...—

P 19, col 1, l 9—delete Magnesium line

P 19, col 2, "Dur. Hard", l 9—change to:
Low Density Polyethylenes, Melt Index
<26 ....C73...—

P 19, col 2, "Dur. Hard", l 10—change to:
Low Density Polyethylenes, Melt Index
200 ....D45...—

Pp 22-27, l 17—delete Hastelloy A line

P 35, col 2-5, l 3—change from 6×10^{6} to: 6×10^{-6}

P 63, col 1, heading—change to: ACI Type

P 84, col 2, l 4—change from 479 to: 39.9

P 84, col 4, l 8—change from 101 to: 8.41

P 148, col 1, l 29—change to: Compression Molding

P 159, col 4, heading—change to: Heat—Mineral

P 164, col 2-3, l 12—change from $>3.4 \times 10^{7}$ to: $>3.4 \times 10^{13}$

P 164, col 4, l 12—change from $>5 \times 10^{7}$ to: $>5 \times 10^{13}$

P 175—Interchange figures for Ten Str (all columns) with those for Dielec Str:
Ten Str, Lengthwise ....
16...13...23...8.5...7.5
Ten Str, Crosswise ....
11...10...18...8...5.5
Dielec Str, 1/16 In. Thick ....
500...250...400...600...175
Dielec Str, 1/8 In. Thick ....
425...185...350...450...175

P 177, col 3, l 2—change from 67 to: 0.160-0.194

P 234, col 1, l 8—change to: Ten Str, 1000 psi

Directory additions on next page

Errata—*Materials Selector* Issue (continued)

DIRECTORY SECTION

P 368, col 3
CASTINGS, DIE — add:
Jersey Plastic & Die Casting Co. (A, H)

P 369, col 1
CASTINGS, INVESTMENT — add:
Haynes Stellite Co., Div. of Union Carbide Corp. (C, E, F)

P 369, col 2
CASTINGS, NONMETALLIC (plastics & rubber) — add:
Houghton Laboratories, Inc. (K)

CASTINGS, PERMANENT MOLD —add:
Eaton Mfg. Co., Foundry Div. (C, F)

P 369, col 3
CASTINGS, SAND — add:
Haynes Stellite Co., Div. of Union Carbide Corp. (C, E)

P 371, col 2
CASTINGS, SHELL MOLD — add:
Quaker Alloys Co. (F)

P 372, col 2
CERAMICS — add:
Laboratory Equipment Corp.
Thermal American Fused Quartz Co.

P 373, col 1
CLAD METALS — add:
Bishop, J. & Co. Platinum Works (F)

P 374, col 3
COATINGS, VITREOUS — add:
Laboratory Equipment Corp.

P 374, col 3
COATINGS AND SURFACES FOR METALS, HARD — add:
Alloy Surfaces Co.

P 376, col 1
EPOXIES — add:
Houghton Laboratories, Inc. (12, 13, 14)

P 377, col 3
FORGINGS — add:
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp. (F)
Herbrand Div., Bingham Herbrand Corp. (F)
Pencoyd Steel and Forge Co. (F)

P 380, col 2
IRON, GRAY (castings) — add:
Goslin-Birmingham Mfg. Co., Inc.
Eaton Mfg. Co., Foundry Div.

P 384, col 1
MOLDINGS, COMPRESSION — add:
Jersey Plastic & Die Casting Co. (K)

P 384, col 3
MOLDINGS, INJECTION — add:
Jersey Plastic & Die Casting Co. (J)

P 385, col 3
MOLYBDENUM AND ITS ALLOYS — add:
General Electric Co., Lamp Wire & Phosphors Dept. (2, 8, 10, 12, 13, 14)

P 389, col 1
SANDWICH MATERIALS — add:
Met-L-Wood Corp.

P 391, col 2
STAMPINGS, PUNCHINGS — add:
Bingham Stamping Div., Bingham Herbrand Corp.

P 392, col 2
STEEL, CARBON — add:
Jones & Laughlin Steel Corp. (2, 8, 9, 12, 13, 14)
Jones & Laughlin Steel Corp., Strip Steel Div. (14)
Athenia Steel Div., National Standard Co. (14)

P 392, col 3
STEEL, CARBON—CASTINGS — add:
Penn Steel Castings

P 393, col 1
STEEL, HEAT AND CORROSION RESISTANT — add:
Jones & Laughlin Steel Corp., Stainless Steel Div. (2, 3)
Athenia Steel Div., National Standard Co. (14)

P 393, col 2
STEEL, HEAT AND CORROSION RESISTANT—CASTINGS — add:
Quaker Alloys Co.

STEEL, LOW ALLOY — add:
Jones & Laughlin Steel Corp., Stainless Steel Div. (2, 9, 13)

P 394, col 1
STEEL, SPECIALTY — add:
Jones & Laughlin Steel Corp. (2, 9, 13)

STEEL, TOOL AND DIE — add:
Jones & Laughlin Steel Corp. (2, 9, 12)

P 395, col 1
TUBING, PIPE — add:
Bundy Tubing Co. (F)

P 396, col 2
TUNGSTEN — add:
General Electric Co., Lamp Wire & Phosphors Dept. (2, 8, 10, 12, 13, 14)

P 396, col 3
URETHANE PLASTICS — add:
Dayton Rubber Co.
American Latex Products Co.

URETHANE RUBBER — add:
Dayton Rubber Co.
American Latex Products Co.

P 398, col 1
WIRE — add:
National Standard Div., National Standard Co. (F)
Athenia Steel Div., National Standard Co. (F)
Worcester Wire Works Div., National Standard Co. (F)

P 398, col 2
WIRE FORMS AND PARTS — add:
Reynolds Wire Div., National Standard Co. (F)

What's new IN MATERIALS

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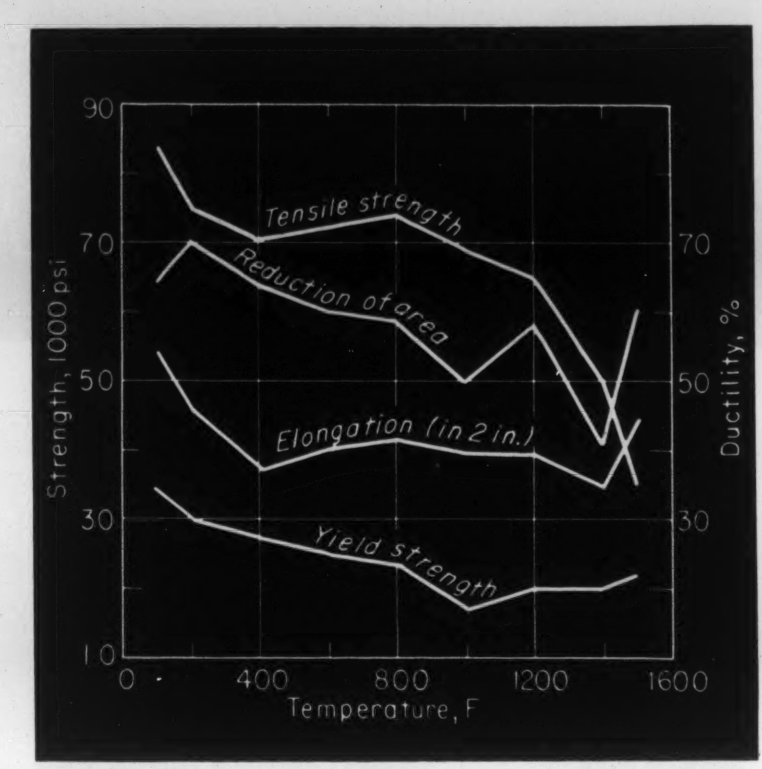

Fig 1—*Short time tensile properties of Croloy 15-15N between room temperature and 1500 F.*

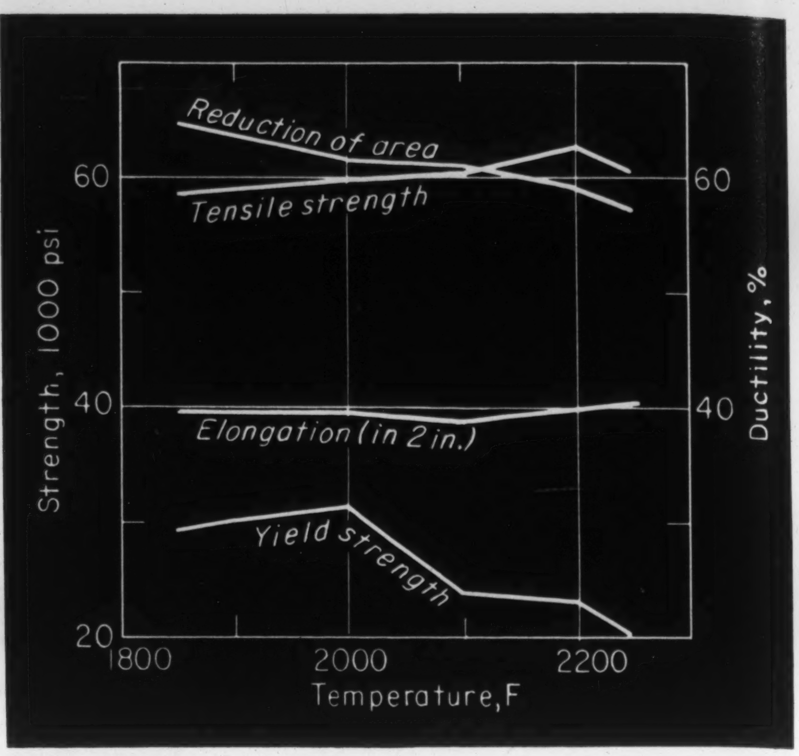

Fig 2—*Influence of solution treating temperature on tensile properties of Croloy 15-15N at 1200 F.*

New Tubing Material Is Strong and Workable

■ A new austenitic heat resistant alloy developed for tubular applications at high temperatures is said to have greater strength than conventional tubular alloys (AISI 300 series), as well as permit fabrication by conventional hot and cold working techniques. The new alloy, designated Croloy 15-15N and developed by Babcock and Wilcox Co., is specifically designed for use at 1200 to 1500 F.

As outlined by J. F. Ewing in a paper delivered at the American Society of Mechanical Engineers' annual meeting in December, the chemical composition of Croloy 15-15N is similar to that of type 316 austenitic heat resistant alloy; additions of tungsten, molybdenum and columbium - tantalum, however, are said to account for the alloy's greater strength (see composition table).

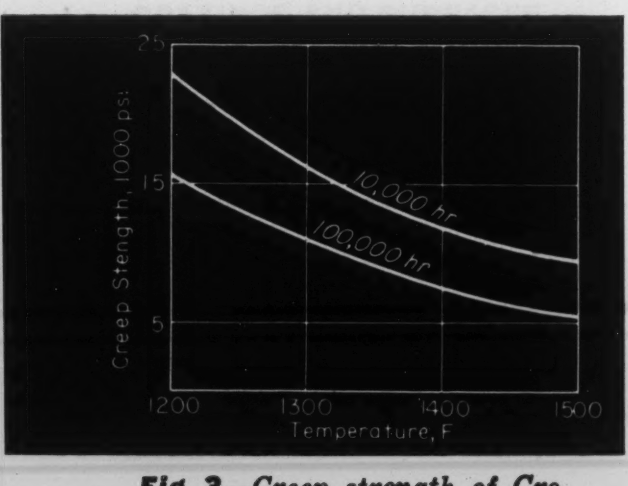

Fig 3—*Creep strength of Croloy 15-15N between 1200 and 1500 F.*

Tensile properties

Typical short time tensile properties between room temperature and 1500 F are presented in Fig 1 for Croloy 15-15N in the 2250 F solution treated condition. As shown, the yield strength decreases from 34,000 psi at room temperature to a minimum of 16,800 psi at 1025 F. However, from 1025 to 1150 F yield strength increases to 19,100 psi; it remains at about 20,000 psi up to 1500 F. This increase is attributed to precipitation. Tensile strength remains good (over 60,000 psi) up to 1200 F and then decreases rapidly.

The influence of solution treating temperatures between 1850 and 2250 F on short time tensile properties at 1200 F is shown in Fig 2. Progressively increasing the solution treating temperature up to 2250 F improves tensile strength. Solution treating above 2000 F, however, decreases the 1200 F yield strength. Tensile elongation is affected very little by the solution annealing treatment, and there is no significant decrease in reduction of area.

Creep properties

Metallographic studies of creep-rupture specimens after testing have shown that Croloy 15-15N has no structural instabilities between 1200 and 1500 F (see Fig 3). A comparison of the new

COMPOSITION OF CROLOY 15-15N

Carbon	0.15 max
Manganese	2.00 max
Silicon	0.75 max
Phosphorus	0.03 max
Sulfur	0.045 max
Nitrogen	0.15 max
Chromium	14.75-18.00
Nickel	13.50-16.50
Molybdenum	1.25-1.85
Tungsten	1.00-1.85
Columbium-Tantalum	0.80-1.30

alloy's creep properties with those of five other austenitic heat resistant alloys widely used for tubular products showed that at temperatures above 1200 F the creep resistance of Croloy 15-15N is noticeably superior.

Corrosion resistance

In order to determine corrosion resistance of Croloy 15-15N, the new material was used as a test probe in a commercial superheater which generates steam at 1250 F and 2000 psi. Metal temperature averaged 1340 F during most of the test. The 2-in. o.d. seamless tubing was subjected to a principal fiber stress of 5040 psi during the test which lasted for more than 7300 hr. Examination of the test probe tubing revealed no evidence of surface instabilities such as corrosion or oxidation. There were no evidences of blistering, craze cracking or exfoliation of scale or metal. Flaring tests after service produced no cracks or tears at either the o.d. or i.d.

Made by a new process . . .

U. S. - Produced Polypropylene Has Good Heat Resistance

■ The first U. S.-produced polypropylene is now in commercial production at Hercules Powder Co.'s Parlin, N. J. plant. From all appearances it is similar to Montecatini's polypropylene, but it is made by a different process.

Hercules' polypropylene, known as Pro-fax, has good heat resistance; has a low specific gravity; has good electrical properties; and has good resistance to oil, water and many common acids. Like Montecatini's resin, the Hercules resin is expected to find wide use in appliances, hospital ware, automotive parts and bottles. (For more information on Montecatini's polypropylene, see MATERIALS IN DESIGN ENGINEERING, Dec '57, p 164 and Jan '58, p 110).

The Hercules product, made from propylene gas, is apparently produced by polymerization techniques different from those developed by G. Natta of Milan Polytechnic Institute; Natta's polymerization techniques are used to produce Montecatini's resin. Hercules has not revealed any details on its process.

Properties

According to Hercules, the high tensile strength, hardness, heat resistance, stiffness, resilience and clarity of Pro-fax, together with its inertness and water resistance, ". . . will complement the usefulness of high density polyethylene and broaden significantly the available markets for plastics, especially those served by wood and metal."

Additional properties listed for the resin are:

1. High impact strength.
2. Ability to withstand sterilization temperatures.
3. Good solvent resistance.
4. Good resistance to staining.

Uses

The company has evaluated many injection molded polypropylene parts, and laboratory and field tests indicate it should be useful for valves, bottles, pipe, (including hot water piping), automotive parts, appliance housings, and laboratory and hospital ware. It also appears to be an important raw material for the manufacture of film for packaging and sheet for vacuum forming. Other suggested uses include extrusion into fibers. (For more information on fibers from isotactic polymers, see MATERIALS & METHODS, May '57, p 203).

Fabrication

Hercules says the new plastic has good molding characteristics and can be shaped and fabricated by any of the procedures common to plastics. When evaluated in existing molds, it yields good parts without die changes or alterations in processing equipment. According to the producer, it can be molded over a broad range of temperatures and molding conditions.

The introductory price for Pro-fax polypropylene resin is 65¢ per lb. The company says ". . . as large scale operating economies are realized, the price will be fully competitive with other plastics materials." The plant in New Jersey is expected to have an annual capacity of 20,000,000 lb.

TYPICAL PROPERTIES OF MOLDED PRO-FAX

PHYSICAL PROPERTIES	
Crystalline Melting Point, F	330
Specific Gravity	0.901
Mold Shrinkage, in./in.	0.015 to 0.020
MECHANICAL PROPERTIES	
Tensile Strength, psi	5000
Tensile Modulus, psi	155,000
Tensile Yield Stress, psi	4970
Tensile Yield Strain, %	15
Ultimate Elongation, %	>220
Flexural Modulus, psi	170,000
Flexural Strength, psi	8100
Izod Impact Strength, ft-lb/in.	
Notched	1.02
Unnotched	>17
Rockwell Hardness	R 93
ELEVATED TEMPERATURE PROPERTIES	
Yield Stress (212 F), psi	1720
Tensile Modulus (212 F), psi	37,000
Heat Distortion Temperature (66 psi), F	221
Deformation Under Load (2000 lb, 6 hr at 122 F), %	2.0
ELECTRICAL PROPERTIES	
Dielectric Constant	2.0
Power Factor	0.0003
ENVIRONMENTAL PROPERTIES	
Water Absorption, %	0.03
Environmental Stress Cracking	None

(more What's New on p 152)

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Chromizing Makes Molybdenum Usable Above 2000 F

■ Chromium diffusion coating (commercially: Chromallizing) has long been known as an efficient method of producing corrosion resistant surfaces on ferrous parts. The process diffuses chromium into the surface of the metal, penetrating all cracks, pores and recesses to form an intimate metallurgical bond. Recently, two modifications have been made in the process which greatly increase its usefulness.

Molybdenum

Of general importance is the fact that the process can now be used to coat certain nonferrous metals—molybdenum, columbium, nickel and cobalt alloys. Of major importance is the claim by Chromalloy Corp. that as a result of this modification, molybdenum can now be successfully utilized at working temperatures in excess of 2000 F.

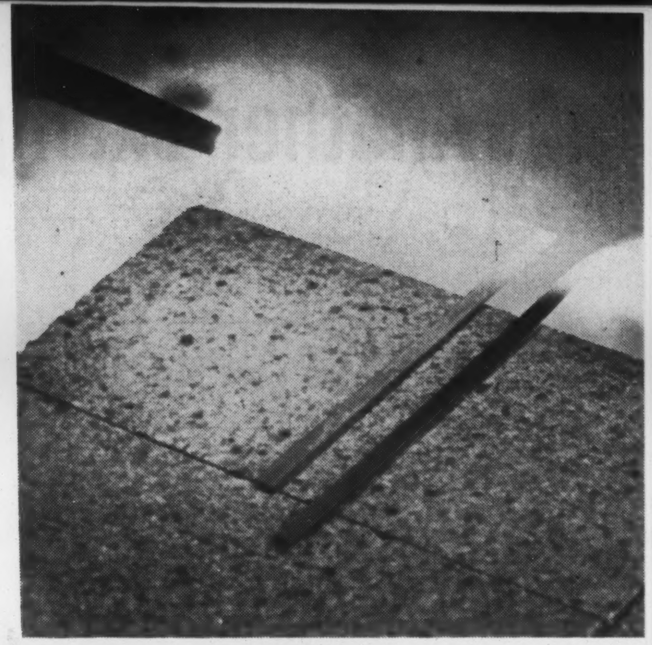
According to Chromalloy, "Until now it has been impossible to take advantage of molybdenum's outstanding high temperature strength, because at high temperatures this metal forms a volatile oxide which leads to rapid erosion and eventual deterioration." Treatment by the new process, designated W-2, is said to provide molybdenum with a high degree of oxidation resistance. In fact, tests have shown that chromium diffusion coated molybdenum outperforms either ceramic coated or electroplated molybdenum. Below is a summary of some of the tests to which the W-2 treated molybdenum has been successfully subjected:

1. Held at 2000 F for 400 hr, cooled, reheated; total of 18 cycles.
2. Held at 2300 F for 100 hr, cooled, reheated; total of 5 cycles.
3. Bent to an angle of 15 deg, held at 2200 F for 48 hr, cooled, reheated; total of 3 cycles; then held at 2350 F for 400 hr, cooled.
4. Artificial surface defects inflicted by Rockwell Brale under 10, 14, 30 and 60-kg loads, heated to 2200 F and held for 5 hr; cooled, reheated to 3000 F, held for 15 min.
5. Oxyacetylene flame heated (2600 F) for 15 sec, quenched in cold oxygen to room temperature in 30 sec; repeated 30 times; then heated to 2200 F and held for 18 hr.

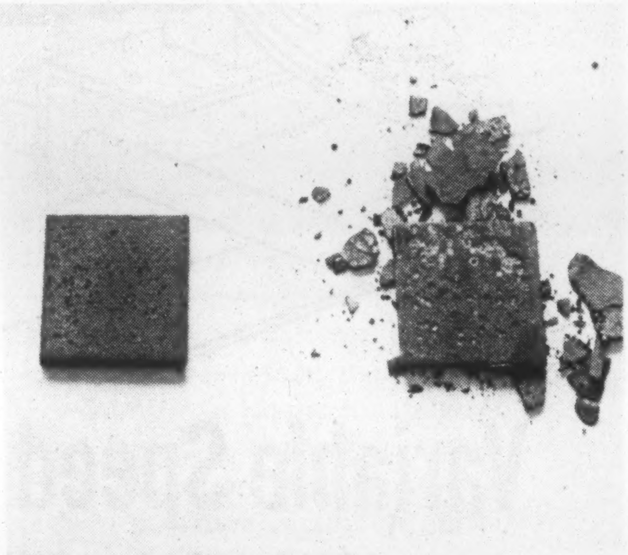
According to Chromalloy, chromium diffusion coated molybdenum is ideal for such applications as gas turbine blades, ram jet flame holders, turbine wheels, gas generator assemblies, thermocouple protection tubes, nuclear reactor rods, heat exchanger tubes, missile combustion chambers and many other high temperature applications.

Columbium

Similar promising applications of the W-2 modification are indicated for columbium. In fact, treated columbium should actually be more suitable than treated molybdenum for certain high temperature applications because, unlike molybdenum, columbium does not form a volatile oxide and can therefore be considered safer in critical applications. Samples of chromium diffusion coated columbium have been exposed to 1800 F for 320 hr and subjected to 13 heating and cooling cycles without failure.



Chromized molybdenum *(left) resists oxyacetylene torch (2600 F); untreated molybdenum (right) gives off volatile oxide vapors.*



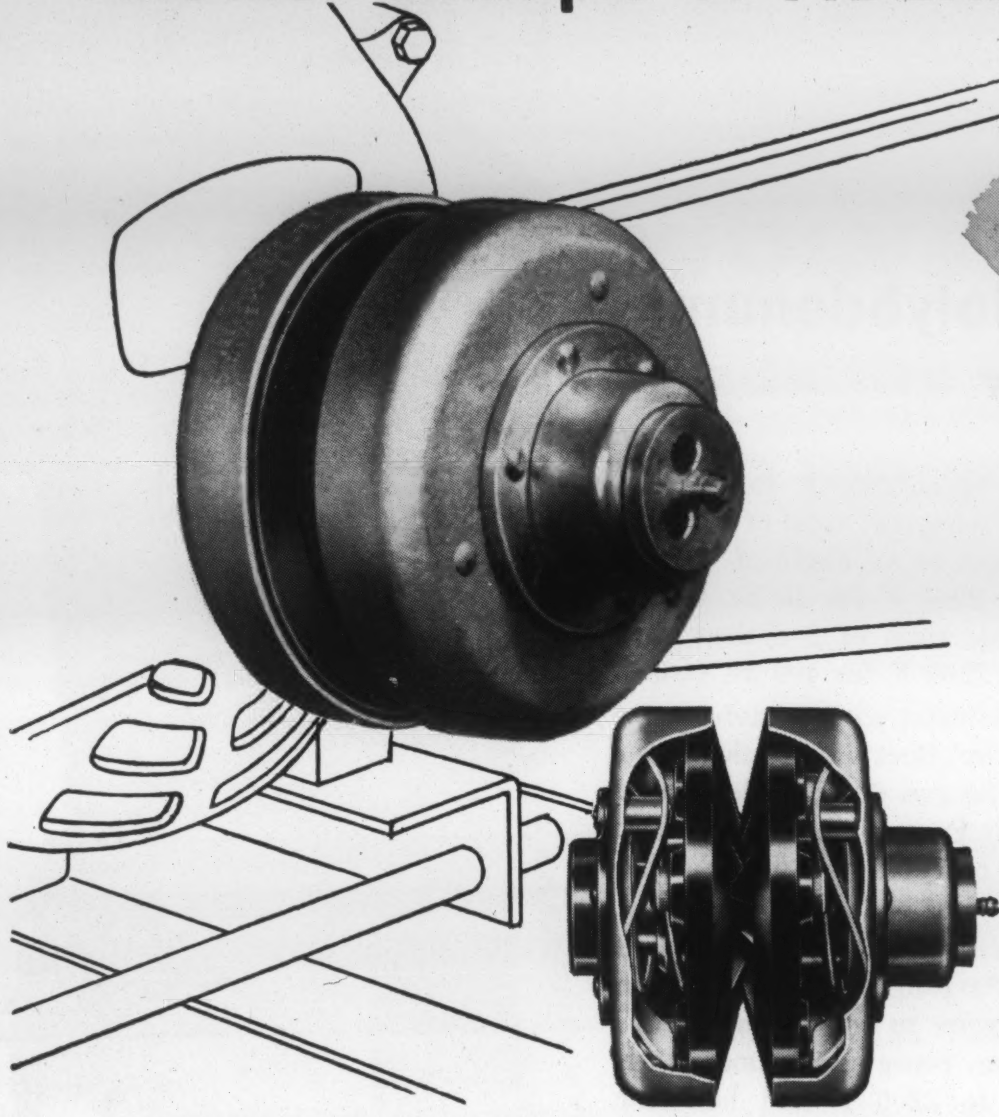
Treated superalloy N-155 *(left) and untreated specimen (right) after 24 hr at 1800-2000 F.*

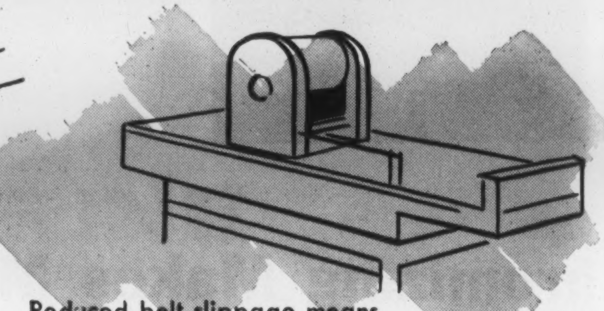
Nickel and cobalt alloys

The second modification of the process, designated SA, is said to provide nickel and cobalt alloys with surfaces that are capable of withstanding prolonged exposure to gases at 1800-2000 F, even in the presence of lead bromide, lead sulfide, sulfur dioxide and other corrosives. This modification is expected to increase the usefulness of these alloys in jet and internal combustion engines and in gas turbines. Chromium diffusion coated nickel and cobalt alloys are also being tested for aircraft piston engine valves and for components in truck engines and nuclear reactors.

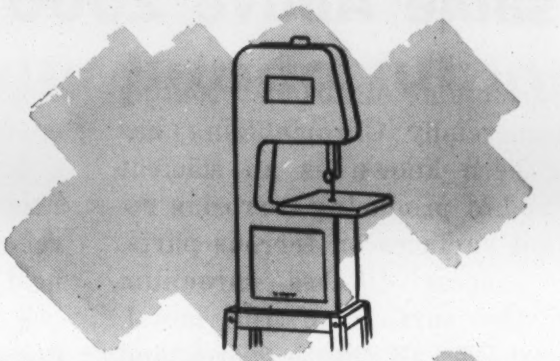
(more What's New on p 159)

Another example of FIBERITE at work . . .

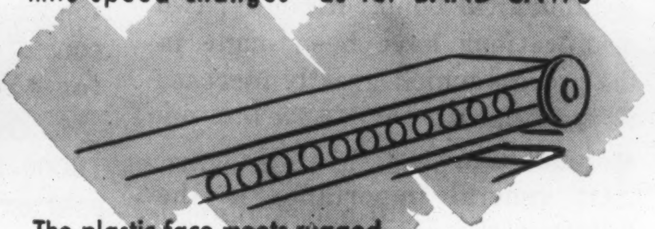




Reduced belt slippage means precise grip—as for DUPLICATORS



This popular "Hi-Lo" pulley permits speed changes—as for BAND SAWS



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Heat Resistant Thermoplastic Has Good Electrical Properties

■ Cymac 325 is the trade name for a new electrical grade thermoplastic that has been added to a family of methylstyrene compounds introduced in early 1956 (see MATERIALS & METHODS, Mar '56, p 145). The new plastic was developed by Plastics and Resins Div., American Cyanamid Co., 30 Rockefeller Plaza, New York 20.

The other methylstyrene compounds, polymethylstyrene (Cymac 400) and acrylonitrile-methylstyrene (Cymac 201), are said to withstand relatively long immersions in boiling water and exposures to similar temperatures of dry heat without significant distortion. All three molding compounds, Cymac 400, 201 and 325, are available in commercial quantities in white and selected colors.

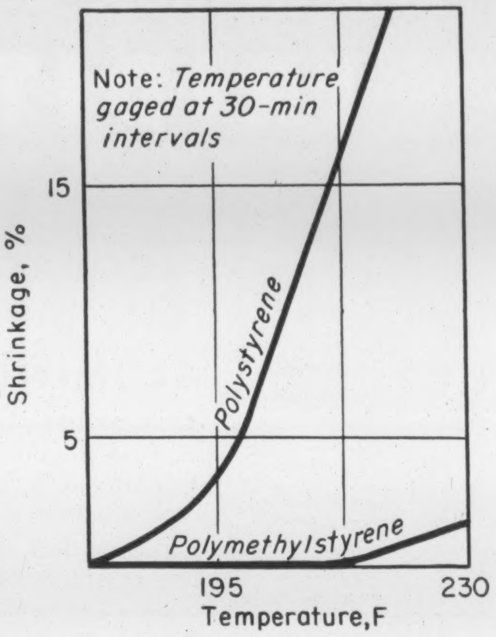
Properties of Cymac 325

A distinctive feature listed for Cymac 325 is its retention of insulating and electrical properties under severe service conditions, such as high temperatures and high humidities. Cyanamid scientists demonstrated the insulating and electrical properties of the thermoplastic with the following tests:

1. A strain insulator molded of Cymac 325 was tested in accordance with specification MIL-A-7965-ASG for antenna components and was found to exceed the 10,000-v minimum radio frequency heating and breakdown requirements set up for the components. Actually, the part withstood 18,000 v at 3.44 in. Hg (equivalent to 50,000-ft altitude) and 3 mc.

TYPICAL PROPERTIES OF CYMAC RESINS

Type ➜	400	325
PHYSICAL PROPERTIES		
Specific Gravity	1.03	1.01
Water Absorption (24 hr), %	0.05	0.05
Burning Rate	Slow	Slow
Mold Shrinkage, in./in.	0.004	0.004
Heat Distortion Temperature, F	213	216
MECHANICAL PROPERTIES		
Tensile Strength, psi	6600	8900
Elongation, %	2.2	5.0
Flexural Modulus, psi	400,000	400,000
Flexural Strength, psi	12,900	10,100
Izod Impact Strength, ft lb/in.	0.33	0.36
Rockwell Hardness	M 76	M 83
ELECTRICAL PROPERTIES		
Dielectric Strength, v/mil	890	1950
Dielectric Constant (100 kcs)	2.52	2.52
Volume Resistivity, ohm-cm	2.6×10^{14}	5.0×10^{17}



Effect of heat *on the shrinkage of polystyrene and polymethylstyrene.*

2. In order to determine radio frequency flashover voltage strength of Cymac 325, Cyanamid scientists used a test procedure in which rms voltage is applied at selected frequencies across a gap of 0.375 in. between stainless steel electrodes, then increased to breakdown in approximately 40 sec. (Resistance to surface failure is an important characteristic of a solid insulator and a high initial value of flashover voltage is desirable for such a part.) Tests were conducted at three frequencies: 2, 18 and 100 mc per sec at 77 F and 100% RH, with moisture condensation on the specimens at 2 and 18 mc.

Upon exposure to 100% RH at 77 F for 96 hr, Cymac 325 loses 27% of its initial flashover voltage strength at 2 mc per sec and 24% at 18 mc. On the other hand, polystyrene, upon exposure to 100% RH at 77 F for 1 hr, loses 35% of its initial flashover voltage strength at 2 mc and 43% at 18 mc.

The test also revealed that Cymac 325 resists the formation of a carbon track between the electrodes and does not blister, deform, heat up or delaminate.

3. Dielectric strength of the thermoplastic was determined in accordance with ASTM short time tests (D 149) in air and oil for

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Either coating provides corrosion resistance superior even to complicated electrolytic treatments in a fraction of the time. These coatings also offer many other valuable characteristics: they have low electrical resistance, they aid in arc-welding, provide a good base for bonding compounds, have no effect on the dimensional stability of close-tolerance parts. Final appearances ranging from clear through yellow iridescence to full brown can be obtained. By dyeing, you can produce red, green, blue, orange or yellow finishes.

IRIDITE #15 for MAGNESIUM

Produces a protective, paint base film with corrosion resistance at least equal to that obtained from long, high-temperature dichromate treatments in a fraction of the time and at room temperature. The appearance of the coating can be varied from light brown to dark brown and black.

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a number of test specimens of different thicknesses.

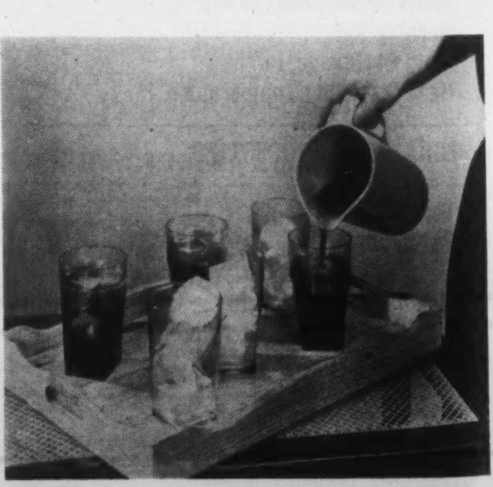
In air: A dielectric strength of 1950 v per mil at 60 cps was recorded for a specimen measuring 10 x 10 in. x 14 mil thick exposed to 35% RH at 70 F.

In oil: A dielectric strength of 2610 v per mil at 60 cps was recorded for a specimen measuring 6 x 6 in. x 13 mil thick at 77 F.

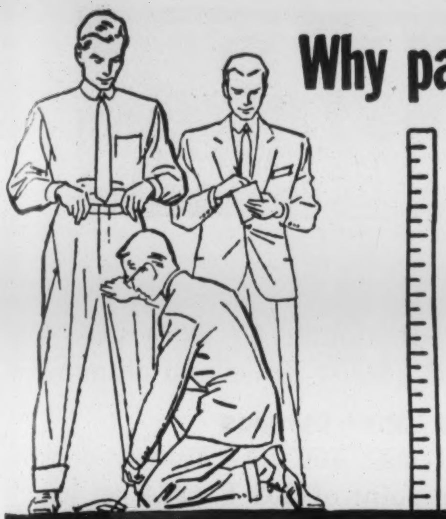
In addition to its good electrical properties, Cymac 325 is said to have good wear resistance. For instance, sleeve bearings machined to close tolerances from extruded Cymac 325 tubing have operated without lubrication on a steel shaft rotating at 1750 rpm at a PV factor of approximately 16,200 with significantly less wear than that for nylon bearings of the same size and tested under the same conditions.

Other properties listed for the electrical grade resin are good heat stability and good resistance to deformation at relatively high loadings and high temperatures.

Fabrication — Cyanamid engineers say that Cymac 325 can be readily molded and extruded in conventional molding equipment; generally, the resin can be molded at temperatures ranging from 450 to 525 F. Molded and extruded parts can be machined to close tolerances by using machining



***Plastics tumblers** molded of Cymac 201 are said to be break resistant and capable of withstanding prolonged immersion in boiling water.*



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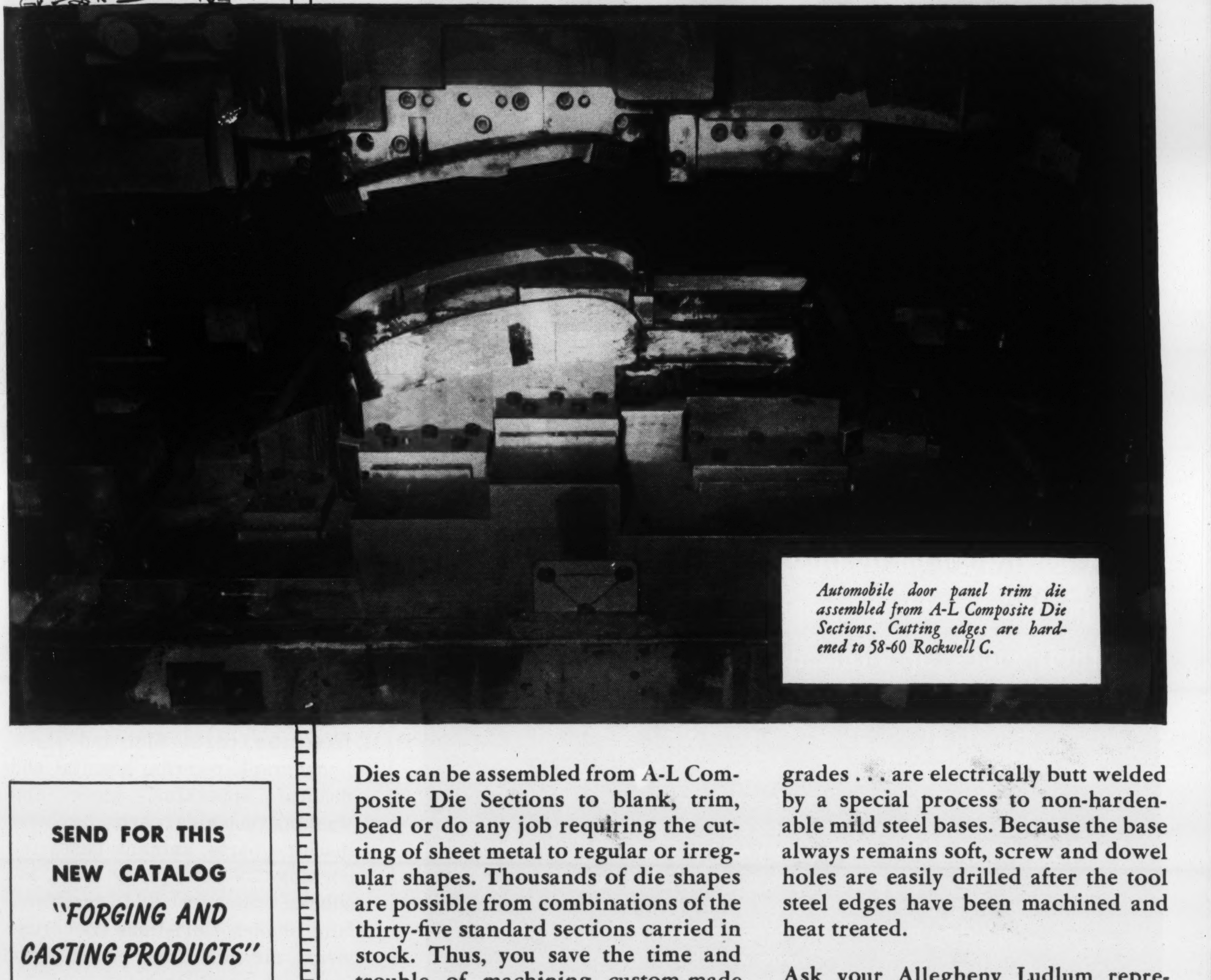

Automobile door panel trim die assembled from A-L Composite Die Sections. Cutting edges are hardened to 58-60 Rockwell C.

Dies can be assembled from A-L Composite Die Sections to blank, trim, bead or do any job requiring the cutting of sheet metal to regular or irregular shapes. Thousands of die shapes are possible from combinations of the thirty-five standard sections carried in stock. Thus, you save the time and trouble of machining custom-made sections from solid stock and minimize the waste of valuable tool steel.

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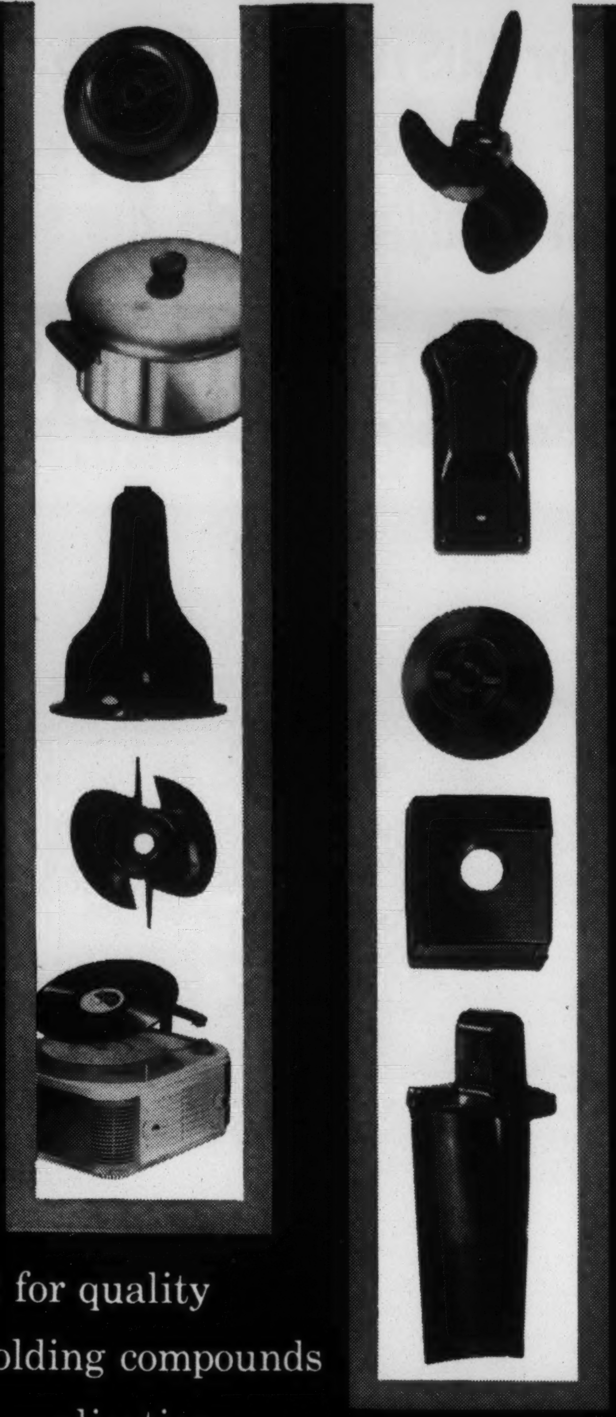

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phenolic molding compounds
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speeds similar to those used for good quality brass and aluminum.

The other Cymacs

Cymac 400 has a heat distortion point of 203 F (264 psi load) which compares favorably with 185 F for general purpose polystyrene and 190 to 199 F for heat resistant polystyrenes. Shrinkage after 30 min in boiling water is 0.2% compared with 1.5% for heat resistant polystyrene.

Cymac 201 has a heat distortion temperature of 207 F (264 psi load). Shrinkage after immersion in boiling water for 30 min, followed by exposure to dry heat at 225 F for 2 hr is 8%, whereas ordinary heat resistant polystyrene exposed to the same conditions is completely warped.

Both Cymac 400 and Cymac 201 are said to have all the desirable characteristics of polystyrene, including good color, clarity and dielectric properties in addition to unusual heat resistance.

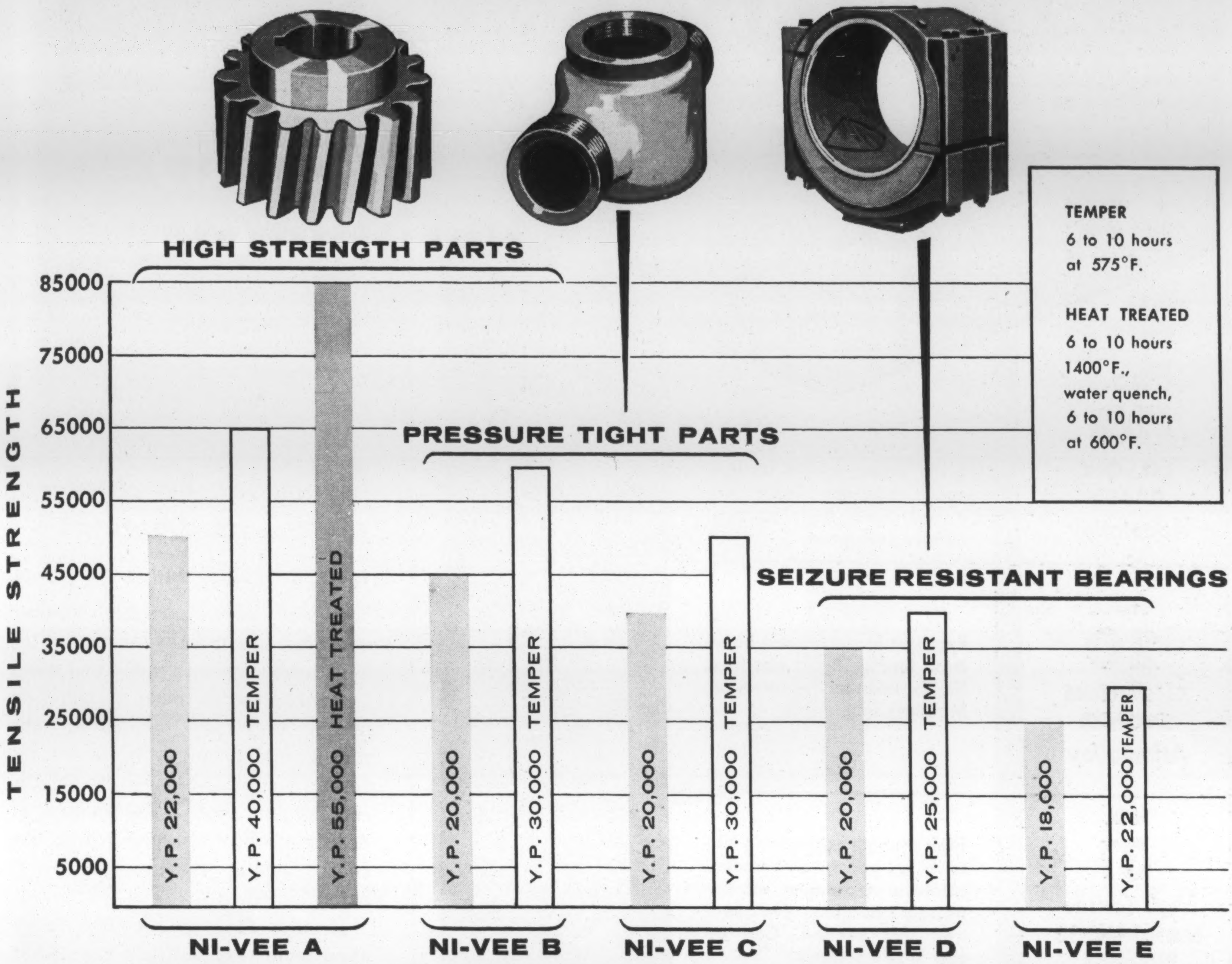
Uses—The molding compounds are being used in the following applications: radio cabinets, industrial battery cases, housewares, tableware, wall tile, refrigerator parts, film and sheet, phonograph records, hospital and medical apparatus, stove and washing machine parts, business machine parts, antenna bases for portable TV sets, picnic ware, insulated pitchers and tumblers, lamp shades, Christmas tree ornaments, air conditioner parts, serving trays and baby ware.

Cyanamid engineers say that both Cymac 201 and Cymac 400 ". . . have replaced polystyrene, styrene-acrylonitrile, acrylic, acetate and polyethylene in certain

Correction

Inadvertently the assistance of Monsanto Chemical Co. was not acknowledged in last month's manual, "Joining and Fastening Plastics."

TYPICAL NI-VEE BRONZE PROPERTIES



5 high-performance bronzes

These versatile Ni-Vee alloys provide a range of properties that satisfies the requirements of most copper-base castings

The chart shows the range of tensile properties of the five Ni-Vee* bronzes and indicates the types of castings made with these alloys.

As you can see, you can satisfy the majority of your specifications for quality copper-base castings from among these five versatile Ni-Vee materials. Their "As Cast" mechanical properties – especially yield strength – surpass those of comparable G and leaded bronzes and red brasses.

The chart also shows what simple heat treatment does to step up their properties. Bear in mind that values taken from the chart are typical. In practice, higher values can be obtained.

Ni-Vee extras

You can expect superior performance from all five Ni-Vee bronzes. For example. Ni-Vee B, C, D, and E (the leaded group) can be used for castings of all three classifications shown. Ni-Vee A provides extreme strength. Ni-Vee E gives you extreme resistance against galling or seizure. The low zinc group (Ni-Vee A, B, D and E) show little tendency to dezincify, insure top-notch resistance to stress corrosion. All five, of course, have the excellent general corrosion resistance of copper reinforced by a 5% nickel 5% tin content.

Helpful booklet gives complete information on Ni-Vee bronzes

"Engineering Properties and Applications of Ni-Vee Bronzes" covers tables of composition, charts on deformation, friction, fatigue, elevated temperature service, electrical resistivity, wear and other engineering data. Write for your copy today.

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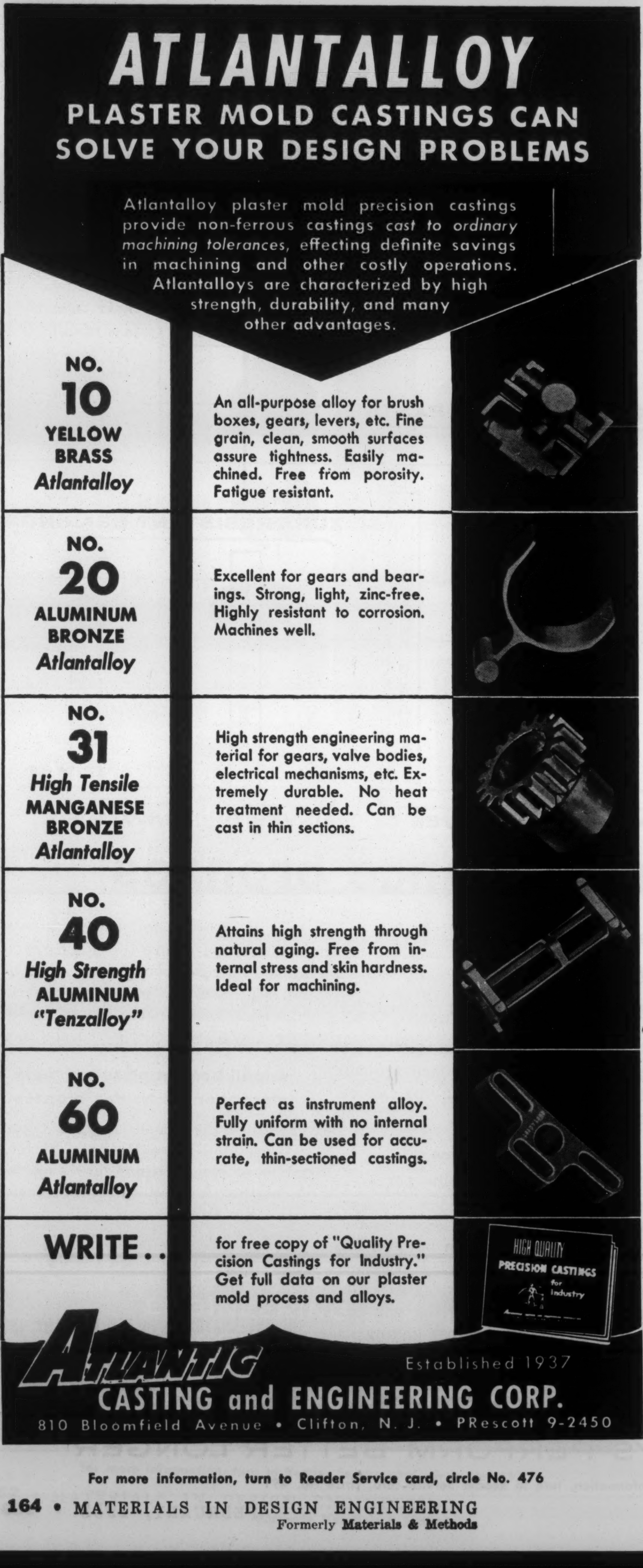

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NO. 31 *High Tensile* **MANGANESE BRONZE** *Atlantalloy*	High strength engineering material for gears, valve bodies, electrical mechanisms, etc. Extremely durable. No heat treatment needed. Can be cast in thin sections.
NO. 40 *High Strength* **ALUMINUM** *"Tenzalloy"*	Attains high strength through natural aging. Free from internal stress and skin hardness. Ideal for machining.
NO. 60 ALUMINUM *Atlantalloy*	Perfect as instrument alloy. Fully uniform with no internal strain. Can be used for accurate, thin-sectioned castings.
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applications." The engineers say that ". . . in each case the Cymac material is used for one or more of the following reasons: 1) heat resistance, 2) dimensional stability, 3) low deformation under load, 4) faster molding cycles, and 5) reduced tendency toward sink marks in heavy sections."

Measuring Fracture of Ceramic Coatings

by D. R. Walker and H. W. Wyatt

Since flame sprayed ceramic coatings are usually of negligible thickness (0.005 to 0.050 in.) when compared to the base material on which they are deposited, the mechanical property of prime interest is not the strength of the coating but rather the amount of deformation or strain which the coating will withstand before it fails.

Results from a recently developed bend test indicate that flame sprayed ceramic coatings should be quite capable of withstanding deformations up to and even beyond yield strains (0.2% offset) of the metals on which they are deposited. The test reveals that flame sprayed zirconia coatings withstand strains exceeding 1.1% before initial cracking, whereas flame sprayed alumina and zirconia-silica coatings initially fail at strains exceeding 0.5% (Fig 1).

The test was developed primarily to estimate the critical strains at which coatings first show failures, such as cracking, spalling or peeling. All of the ceramic coatings evaluated in the test were "Rokide" coatings produced by Norton Co., Worcester, Mass.

Test procedure

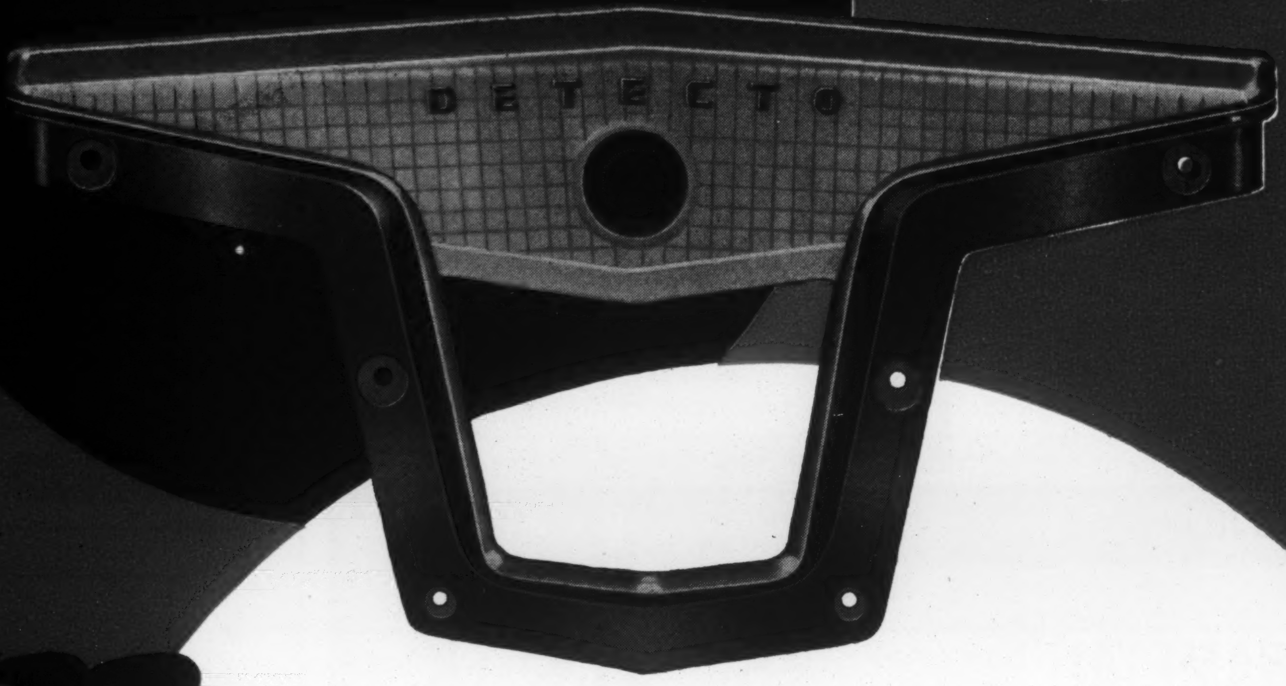
The room temperature test consists of the following steps:

1. Zirconia, alumina and zirco-

The authors, Walker and Wyatt, are associated with the Research and Advanced Development Div., Avco Mfg. Corp.

any way you weigh

CUSTOM INJECTION-MOLDING SERVICE...



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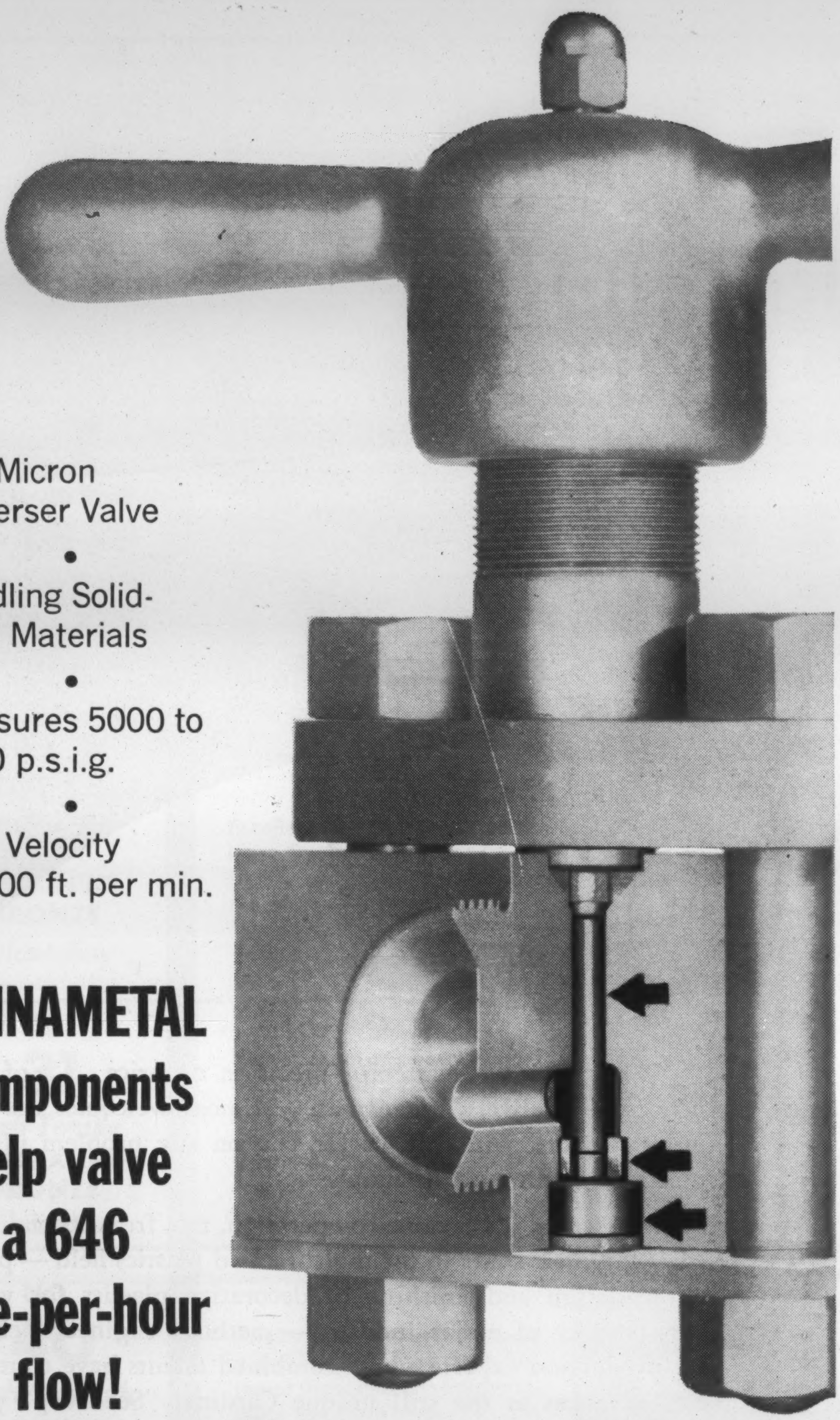

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nia-silica ceramic coatings are flame sprayed onto copper beams. The beams are ceramic coated on both the top and bottom sides to determine coating behavior in compression as well as in tension; the coating keeps the neutral axis of the beam at the center line (neglecting changes in elastic modulus of the coating with strain).

2. The beam is subjected to a

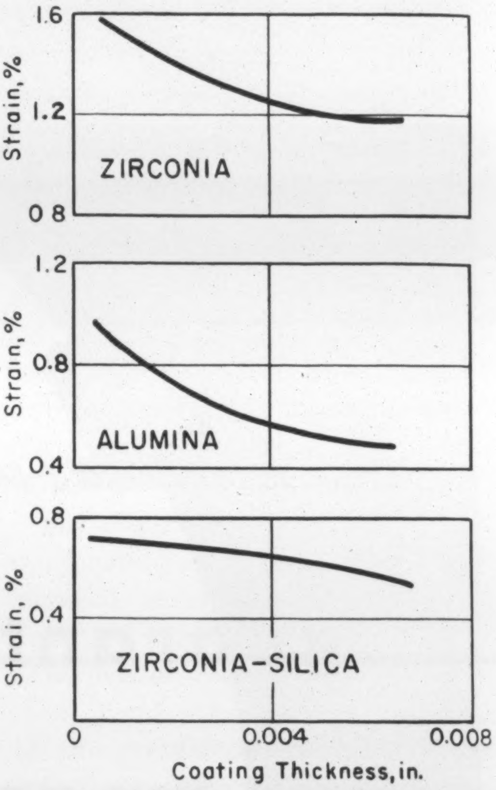
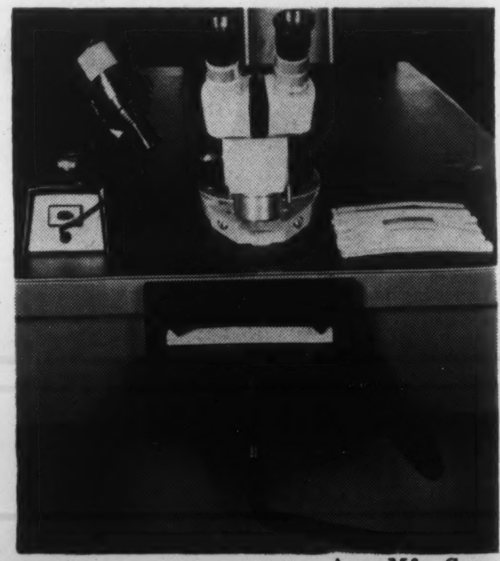
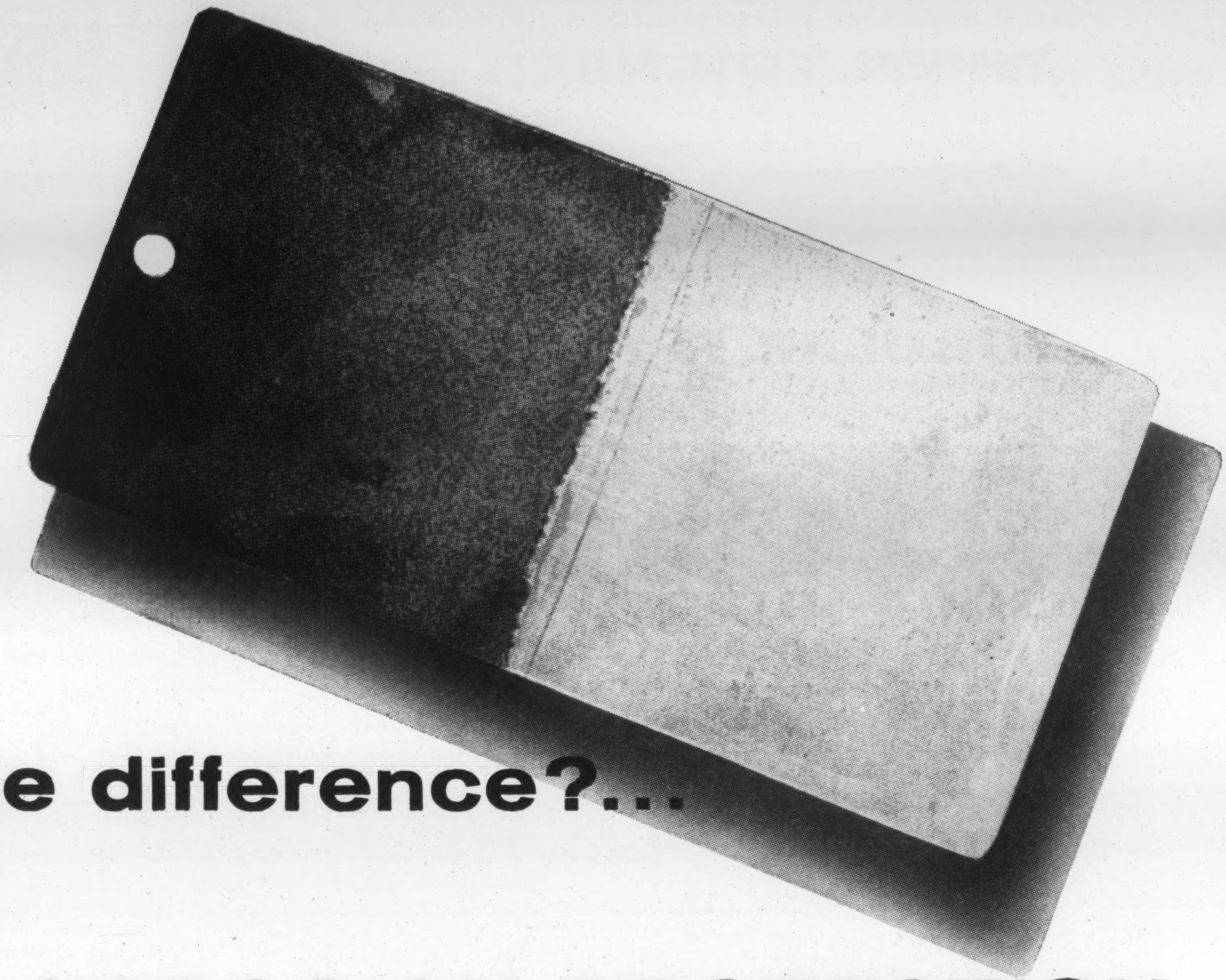


Fig 1—*Strain at initial cracking vs coating thickness for three coatings.*



Avco Mfg. Corp.

Fig 2—*Apparatus used to determine deformation characteristics of flame sprayed ceramic coatings.*



The difference?...

CORROSION PROTECTION with SOLVAY SODIUM NITRITE

(plus monosodium phosphate)

The corrosion on the left side of this sample of common sheet steel developed during 2 weeks of storage under an outdoor shed roof. Before the specimen was placed there, the right side was dipped in a heated (160°F.) water bath containing 2.7% Solvay Sodium Nitrite and 0.3% monosodiun phosphate.

This simple inexpensive treatment offers a practical method of protection for iron or steel sheets, tubes, bars or semi-finished parts during storage or between processing steps. It is easy to apply and will not affect normal skin. Although not generally recommended for uncovered outside storage, the film produced by sodium nitrite and monosodium phosphate is substantially more resistant to moisture than that formed by sodium nitrite alone.

This is just one in the broad range of applications of Solvay Sodium Nitrite for corrosion protection. It can be used as a spray, a dip, or in circulating water systems.

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four point loading to produce a constant bending moment across the center third of the beam span.

3. Deflection of the beam under the two inner loading points is determined by simply noting the number of turns of a screw.

4. Cracking of the top ceramic coating is observed with a 25X microscope which is continuously focused on the beam as the screw is turned (see Fig 2).

5. The tensile strain at initial cracking of the ceramic coatings is determined according to the relation:

$$\epsilon = \frac{27d\,(h + 2t)}{5l^2}$$

where ϵ = strain
d = deflection of the beam at the center loading points
h = base metal thickness
t = coating thickness
l = beam span

What the test shows

As shown in Fig 1, the strain required for initial cracking increases with decreasing coating thickness for all three coatings.

Most of the coated beams first show signs of failure in the form of small, transverse cracks on the tensile side of the beam; however, several beams, particularly those thinly coated with alumina, buckle on the compressive side. This indicates a weakness in the mechanical bond of the ceramic coating to the metal (see Fig 3).

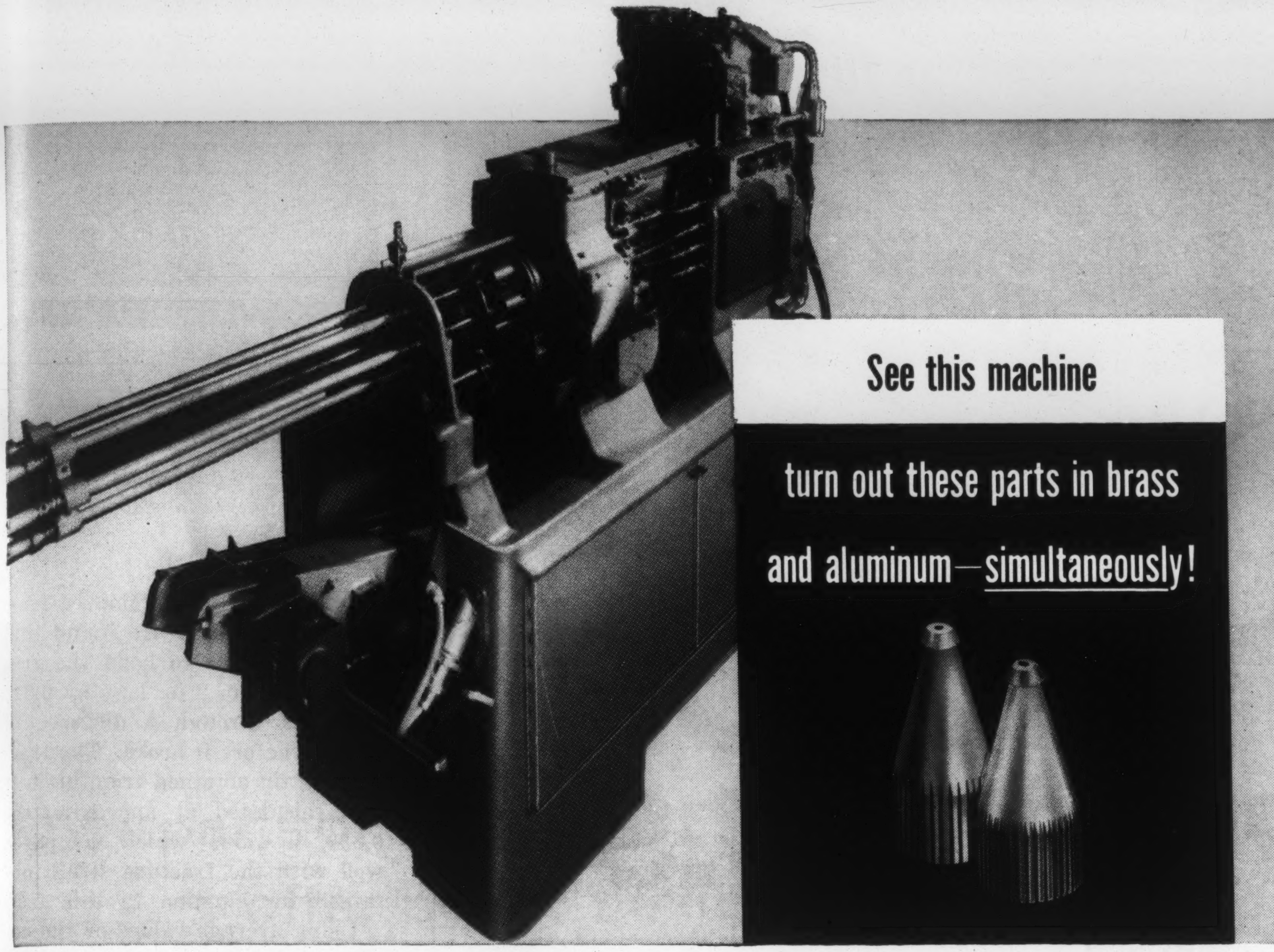
In order to determine the strain required to produce the second and third cracks, loading is continued beyond the strain required for initial cracking. It appears that the second crack follows the first within a strain increment of approximately 0.1%, and the third crack follows the first crack within an increment of 0.15%.

Thermal shock resistance

Neil N. Ault, writing in the Mar '57 issue of the *Journal of the American Ceramic Society*, describes a crude bending test made on a cantilever beam of alu-

BETTER MACHINING STARTS WITH ALCOA SCREW MACHINE STOCK

Alcoa proved it in Cleveland . . . now will prove it in other cities



See screw machine parts produced in aluminum at less cost than steel or brass

When Alcoa and National Acme Company sponsored a machining demonstration in Cleveland last September, 700 design and production engineers and purchasing people saw aluminum and brass parts produced *simultaneously* on a six-spindle automatic screw machine—saw documented evidence that screw machine parts can be produced cheaper in aluminum than in brass or steel. Many expressed frank amazement at the cost comparisons shown.

Here is eye-opening machining news for all industry. Now *you* can see this demonstration, which Alcoa will sponsor in Chicago,* Boston, New York, Detroit, Los Angeles and other important centers.

If your function is design or production of products that use screw machine parts, you will find the Alcoa machining demonstration an enlightening experience. You will see how aluminum offers the ultimate in design freedom because it's so workable, so easy to machine—because it gives better finishes including anodized color. You will see the new color movie about Alcoa Screw Machine Stock, "The Four Amazing Alloys."

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Yes, I want to attend the Alcoa machining demonstration nearest my area__________________.

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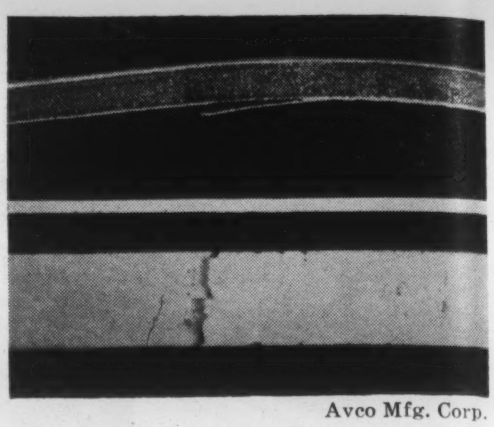

Avco Mfg. Corp.

Fig 3—*Typical cracking and spalling of compression side of ceramic coated beam.*

mina that had been removed from its base material. He found that it was possible to bend the free end of a beam 2 in. long by 0.013 in. thick through a distance of 1⅝ in. before it broke. The fracture strain obtained from his test was calculated at approximately 0.8%, a value which compares well with the fracture strain obtained for alumina in this test.

Using average values of the coefficients of thermal expansion as obtained by Ault, together with minimum cracking strains obtained in this test, it may be estimated that a temperature differential of more than 2000 °F can be sustained by zirconia coatings, whereas a temperature differential of more than 1200 °F can be sustained by alumina and zirconia-silica coatings.

Vacuum Degassing Cleans Up Metals

The refinement of steel in tonnage quantities by pouring it in a sustained stream into a vacuum chamber to remove dissolved gases is now a practical and economical process, according to K. C. Taylor of F. J. Stokes Corp. Mr. Taylor gave his views at the Second International Metallurgical Congress, sponsored by the American Society for Metals in Chicago.

In his paper, Mr. Taylor disclosed that a 250-ton heat of alloy

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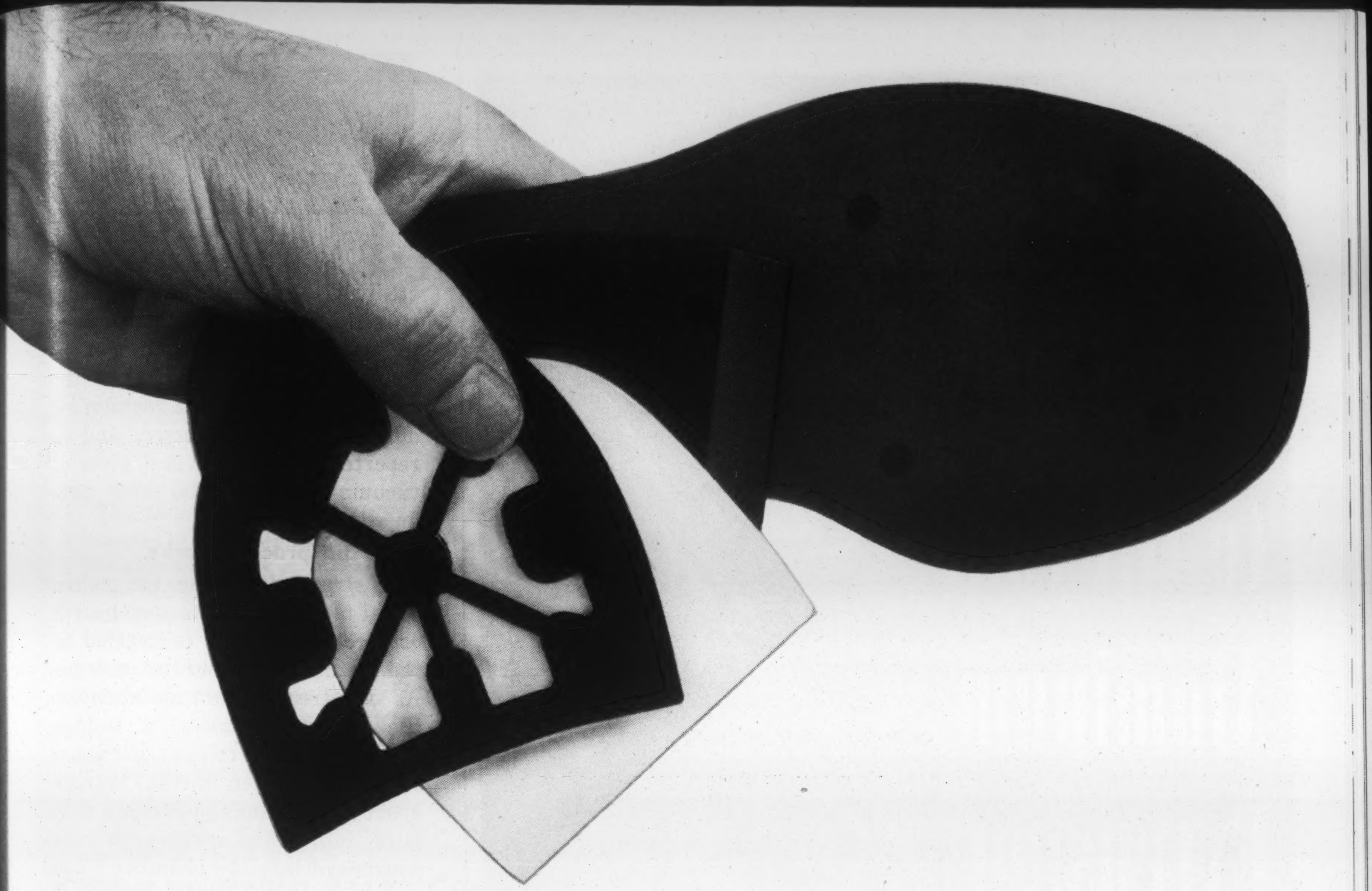

Shoe parts of **TENITE POLYETHYLENE**

offer better flexibility
easier workability
improved moisture resistance
longer life

Plastics are becoming more important every day in shoe construction. The midsole, Dutchman heel pieces, and heel base shown above, for example, illustrate new uses of Tenite Polyethylene by Endicott-Johnson Corporation, a leading name in the shoe industry.

Tenite Polyethylene is a plastic with properties useful to shoe manufacturers. It is light in weight and resists chemical attack, aging and moisture. It is easy to form; parts can be molded, or cut from extruded sheet. It can be supplied in colors.

Endicott-Johnson cite numerous benefits from their use of Tenite Polyethylene. Dutchman heel pieces, they report, formerly were made of fibre and leather. By using Tenite Polyethylene, they now have a material more adaptable to rounding and skiving, which permits production of better-fitting shoes. The new heel pieces also have greater flexibility and moisture resistance—two important considerations for any heel piece.

Their heel bases formerly were made of rubber. By switching to plastic, Endicott-Johnson feel that their new bases are more serviceable and that quality control has been made more precise.

Midsoles formerly were made of leather. Here again, the change to polyethylene has meant improvements in workability, flexibility and moisture resistance.

Today, many industries are using Tenite Polyethylene in place of traditional materials. Perhaps you, too, have a product that could be given improved performance or longer life if made of this versatile plastic. For more information, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

TENITE
POLYETHYLENE
an Eastman plastic

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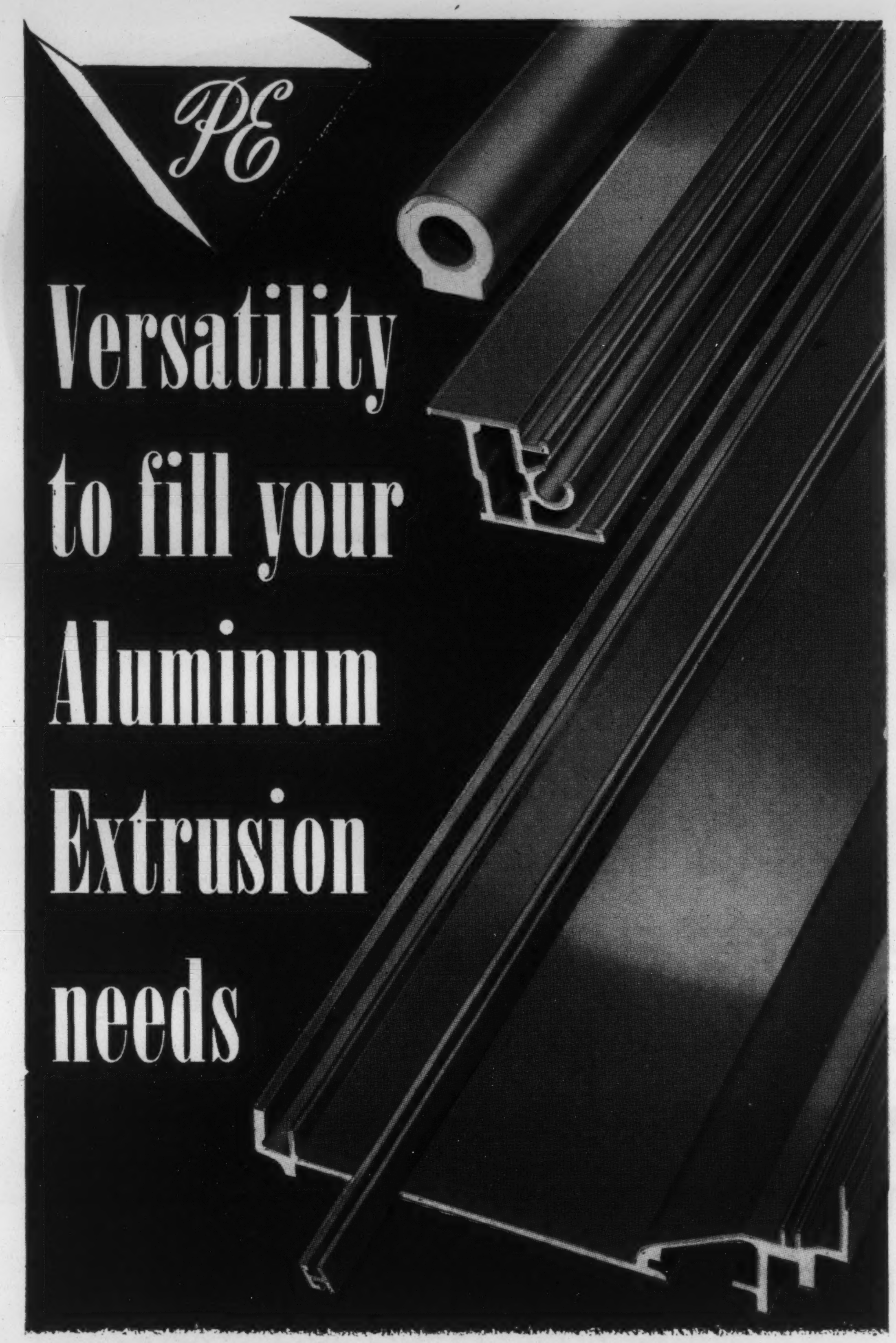

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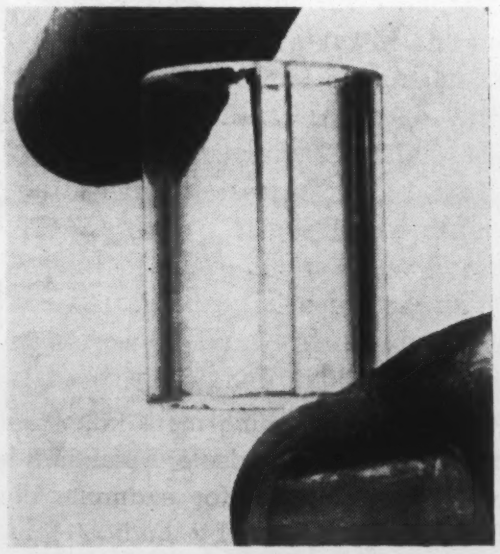
steel has successfully been degassed by vacuum stream degassing methods. This heat is more than 100 times larger than the capacity of the largest vacuum induction melting furnace, and is reported to be the largest piece of vacuum refined metal ever produced.

How the process works

In stream degassing, the molten metal tapped from the open hearth or electric furnace is carried to the vacuum chamber by a ladle. As the stream of hot metal enters the vacuum chamber, a sudden drop in pressure releases the gases from the molten metal, tearing apart the stream and causing it to burst into a fine spray as it falls downward into the chamber. The spray may expand to a width of several feet. This diffusion of the



Heat resistant glass—Because of its low coefficient of expansion and chemical inertness, the silica glass tubing shown above can withstand extreme temperature differentials and is unaffected by close contact with reactive and corrosive materials over a long period of time. Developed by Corning Glass Works, it can withstand temperatures as high as 1600 F and is capable of transmitting short wavelength infrared and ultraviolet rays. It is available in diameters ranging from ⅛ to 3 in. and in lengths from 12 to 36 in.

For more information, turn to Reader Service card, circle No. 502

How

CERROTECHNICS

can save you

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The term CERROTECHNICS refers to the technology of using bismuth alloys (CERRO ALLOYS) in some 63 known industrial operations. It can save you substantial time and money in: anchoring stationary machine parts . . . holding permanent magnets . . . securing punches and dies . . . reclaiming cracked dies . . . bending thin-walled tubing . . . making molds for plastics . . . electroforming molds . . . reproducing master patterns . . . filling blow holes in castings . . . making chuck jaws . . . and handling many other industrial tasks.

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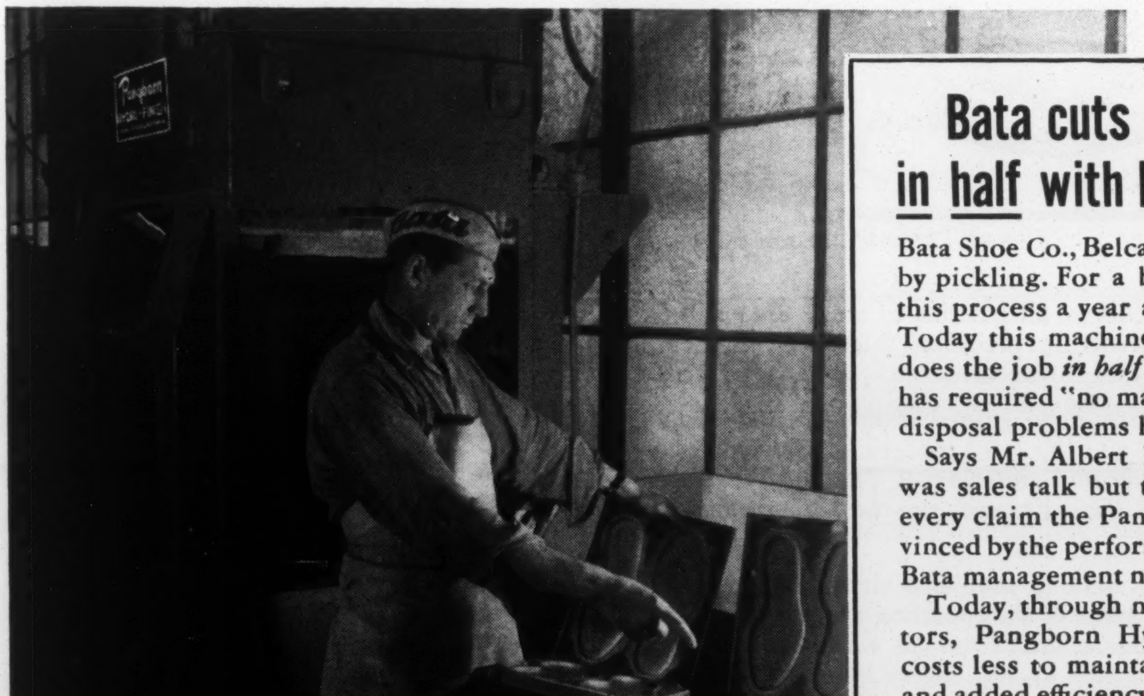


Bata cuts mold cleaning time in half with Pangborn Hydro-Finish

Bata Shoe Co., Belcamp, Md., used to clean shoe molds by pickling. For a better cleaning job, Bata replaced this process a year ago with Pangborn Hydro-Finish. Today this machine gives Bata top quality cleaning, does the job *in half the time* required by pickling and has required "no maintenance whatsoever." Also, acid disposal problems have been eliminated.

Says Mr. Albert Kotras, Research, "We thought it was sales talk but the Hydro-Finish has lived up to every claim the Pangborn representative made." Convinced by the performance of its Hydro-Finish machine, Bata management now plans to order a second one.

Today, through new design and use of air jet sluriators, Pangborn Hydro-Finish costs less originally, costs less to maintain and gives you easier handling and added efficiency. Write for Bulletin 1403 to PANGBORN CORP., 1700 Pangborn Blvd., Hagerstown, Md. *Mfrs. of Blast Cleaning and Dust Control Equipment.*

USE PANGBORN HYDRO-FINISH FOR:

Deburring • Surface finishing • Finishing threaded sections • Improving cutting tool life • Maintaining dies and molds • Removing grinding lines • Removing heat treat scale • Preparing surfaces for coatings, platings, etc.

Pangborn
BLAST CLEANS CHEAPER

For more information, turn to Reader Service card, circle No. 448

metal exposes a large amount of its surface area to the vacuum which eliminates most of the contained gases.

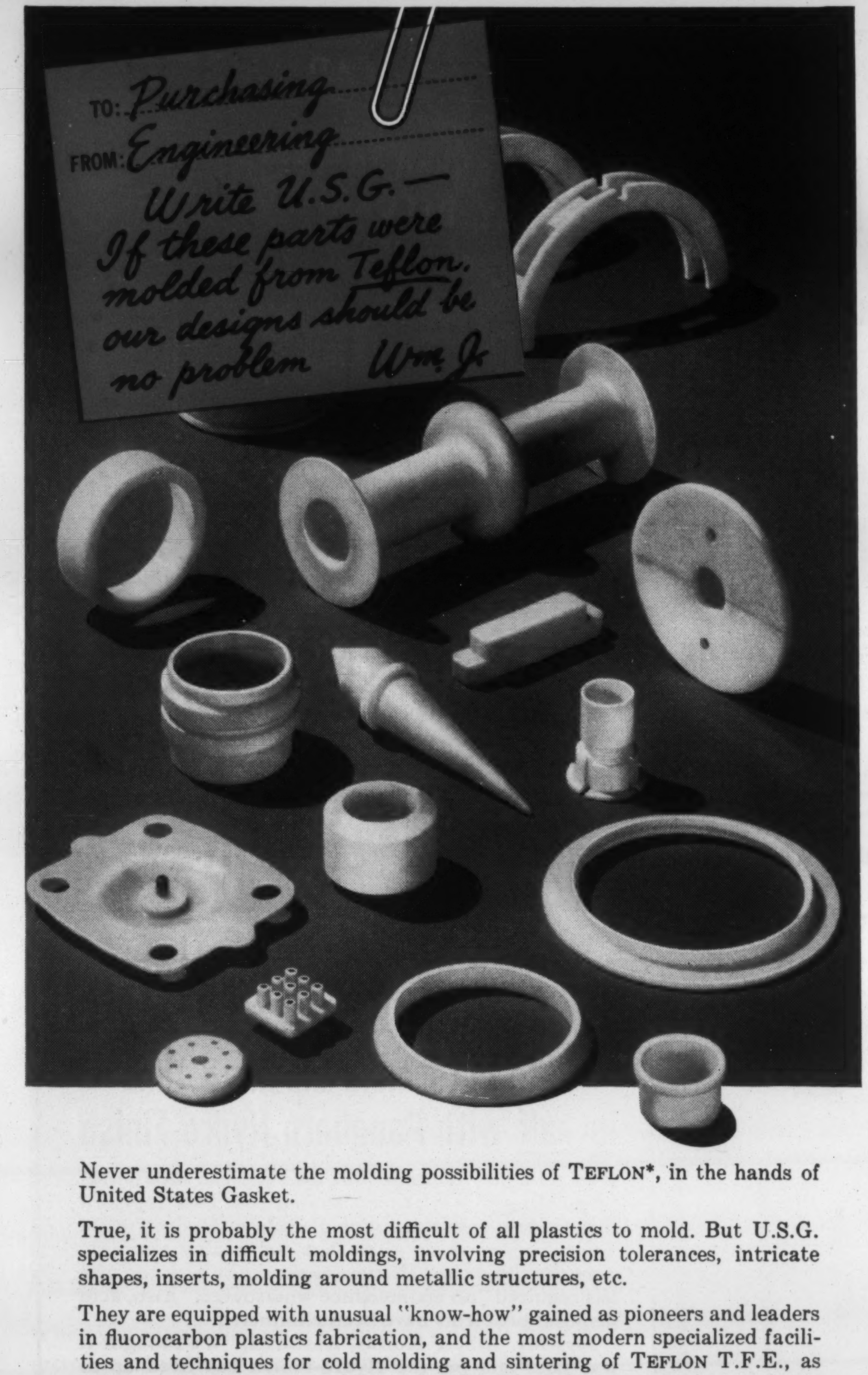
In price, stream degassing is much cheaper than other metal purifying methods, acording to Mr. Taylor. He outlined the costs of three metal refining processes as follows: 1) induction melting, 40¢ per lb; 2) consumable electrode melting, 20¢ per lb; and 3) stream degassing, 1¢ per lb. In addition to price, other advantages outlined by Mr. Taylor are:

1. Hydrogen content is reduced to below 1.5 ppm.
2. Ductility is increased by 15% or more, which means easier machining and forging.
3. Grain size is reduced.
4. Oxygen content is reduced.
5. Heat treating cycles are greatly shortened.

Bath Produces Bright Lead Electroplates

Recent research by J. Vaid and T. L. Rama Char of the Indian Institute of Science, Bangalore, India, indicates that fine grained, bright and adherent lead coatings can be electrodeposited on metals from a pyrophosphate bath. Lead is usually electrodeposited on metals from a fluosilicate, fluoborate or sulfamate bath.

The work of Vaid and Char, reported in the July '57 issue of the *Journal of the Electrochemical Society*, consisted of adding sodium pyrophosphate to lead nitrate in a plating bath. The resulting solution had good throwing power, was easy to control and produced a grayish-white, nonporous lead coating 0.001 in. thick in 18 min at 25 amp per sq ft. The investigators found that when gelatin was added to the bath, the deposit became finer grained and brighter. Corrosion tests performed on the electroplate, in-


TO: Purchasing
FROM: Engineering
Write U.S.G. — If these parts were molded from Teflon, our designs should be no problem Wm. Jr.

Never underestimate the molding possibilities of TEFLON*, in the hands of United States Gasket.

True, it is probably the most difficult of all plastics to mold. But U.S.G. specializes in difficult moldings, involving precision tolerances, intricate shapes, inserts, molding around metallic structures, etc.

They are equipped with unusual "know-how" gained as pioneers and leaders in fluorocarbon plastics fabrication, and the most modern specialized facilities and techniques for cold molding and sintering of TEFLON T.F.E., as well as the injection molding of KEL-F† and the new thermoplastic TEFLON F.E.P.

Send us your difficult fluorocarbon molding problems for quotations. And call upon us, too, for your requirements of fluorocarbon and nylon sheets, discs, tape, rods, tubing, bars, cylinders, etc., from the world's largest and most complete stocks.

For prompt service, contact one of The Garlock Packing Company's 30 sales offices and warehouses throughout the U.S. and Canada, or write

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United States Gasket *Plastics Division of* **GARLOCK**

For more information, turn to Reader Service card, circle No. 364

HIGH PURITY RARE EARTHS

Available in quantities at surprisingly low cost

a report by LINDSAY

A few months ago, in one of these reports, we presented this table of high purity rare earth and yttrium oxides. We anticipated inquiries, of course, but the flood of letters requesting detailed information really startled us.

What interests us particularly, and will you, is the fact that so many research people are intrigued with the practical possibilities of these unique materials. The large amount of research now being done on high purity rare earth oxides in a wide variety of industries encourages us to suggest the likelihood that they may offer you opportunities for potentially profitable investigation.

Already, in a little more than two years since rare earths in purities up to 99.99% became available in commercial quantities, they are being used as basic production materials in many chemical and industrial operations.

Production Up—Costs Down

We have expanded our production facilities to keep up with demand and now have more than 100 ion exchange columns in continuous operation. Quantities are large enough to assure you a dependable source of supply. Prices are low enough to make their use on a production basis economically sound.

Most of the high purity rare earth and yttrium oxides are available for prompt deliveries in quantities of an ounce to hundreds of pounds.

We can't tell you how to use high purity rare earths in your production operations, nor can we promise that one of them may be the missing element in new process or product developments on which you are working. We *can*, however, supply you with data which you will find interesting, revealing and quite possibly of immediate importance to you.

TYPICAL MAXIMUM IMPURITIES IN LINDSAY PURIFIED RARE EARTH AND YTTRIUM OXIDES

ATOMIC NO.	OXIDE	CODE	PURITY	% RARE EARTH MAXIMUM IMPURITIES AS OXIDES
57	La_2O_3. LANTHANUM OXIDE	528	99.99	0.01 Pr, 0.001 Ce.
		529	99.997	0.0025 Pr, 0.0005 others
58	CeO_2. CERIC OXIDE	215	99.8	0.2 (largely La + Pr + Nd).
		216	99.9	0.1 (largely La + Pr + Nd).
59	Pr_6O_{11}. PRASEODYMIUM OXIDE	726	99	1 La + Nd + smaller amounts of Ce and Sm.
		729.9	99.9	0.1 Ce + Nd.
60	Nd_2O_3. NEODYMIUM OXIDE	628	95	1-4 Pr, 1-4 Sm, 0.5-1 others.
		629	99	0.1-0.4 Pr + 0.1-0.4 Sm + 0.5 others.
		629.9	99.9	0.1 (largely Pr + Sm).
62	Sm_2O_3. SAMARIUM OXIDE	822	99	0.2-0.7 Gd, 0.2-0.6 Eu, and smaller amounts of others.
		823	99.9	0.1 (largely Nd + Gd + Eu).
63	Eu_2O_3. EUROPIUM OXIDE	1012	98-99	1-2 Sm + smaller amounts of Nd + Gd + others.
		1011	99.8	0.2 (largely Sm + Gd + Nd).
64	Gd_2O_3. GADOLINIUM OXIDE	928.9	99	1 Sm + Eu + trace Tb.
		929.9	99.9	0.1 Sm + Eu + trace Tb.
65	Tb_4O_7. TERBIUM OXIDE	1803	99	1 Gd + Dy + Y.
		1805	99.9	0.1 Gd + Dy + Y.
66	Dy_2O_3. DYSPROSIUM OXIDE	1703	99	1 (largely Ho + Y + Tb + small amounts of others).
		1705	99.9	0.1 Ho + Y + traces of others.
67	Ho_2O_3. HOLMIUM OXIDE	1603	99	1 (largely Er + Dy + small amounts of others).
		1605	99.9	0.1 Er + Dy + traces of others.
68	Er_2O_3. ERBIUM OXIDE	1303	99	1 Ho + Dy + traces Yb and Y.
		1305	99.9	0.1 Ho + Tm.
69	Tm_2O_3. THULIUM OXIDE	1405	99.9	0.1 Er + Yb + trace Lu.
		1403	99	1 Er + Yb + trace Lu
70	Yb_2O_3. YTTERBIUM OXIDE	1201	99	1 Er + Tm + trace Lu.
		1202	99.9	0.1 Tm + trace Lu + Er.
71	Lu_2O_3. LUTETIUM OXIDE	1503	99	1 Yb + Tm + traces of others.
		1505	99.9	0.1 Yb + Tm + traces of others.
39	Y_2O_3. YTTRIUM OXIDE	1112	99	1 Dy + Gd + traces Tb and others.
		1115	99.9	0.1 Dy + Gd + traces Tb
		1116	99.9+	Approx. 0.05 Dy + Gd.

For detailed information and prices, write for our bulletin
"Purified Rare Earth and Yttrium Oxides"

PLEASE ADDRESS INQUIRIES TO:

LINDSAY CHEMICAL COMPANY

World's Largest Producer of Thorium and Rare Earth Chemicals

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STANDARD AND CUSTOM MADE

Items No. 1 and 2 are standard. Other Griddles for gas and electric ranges are custom made with our exclusive DURAGLAZE or SATIN finishes. They are most popular because they do not discolor easily and cleaning is quick and simple.

Many other styles not shown are available as standard items. Write for full particulars.

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Mr. CHARLES E. BURT
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Rochester 12, N. Y.
CHarlotte 2-0623-M

For more information, turn to Reader Service card, circle No. 394

cluding four months exposure to corrosive atmospheres, indicate it has good corrosion resistance.

Improved Varnishes for Class F Uses

Two companies have recently brought out improved polyester varnishes for Class F electrical insulations. One varnish is specifically intended to be used with an improved polyester enamel. Both companies say their respective products are able to meet high temperature requirements.

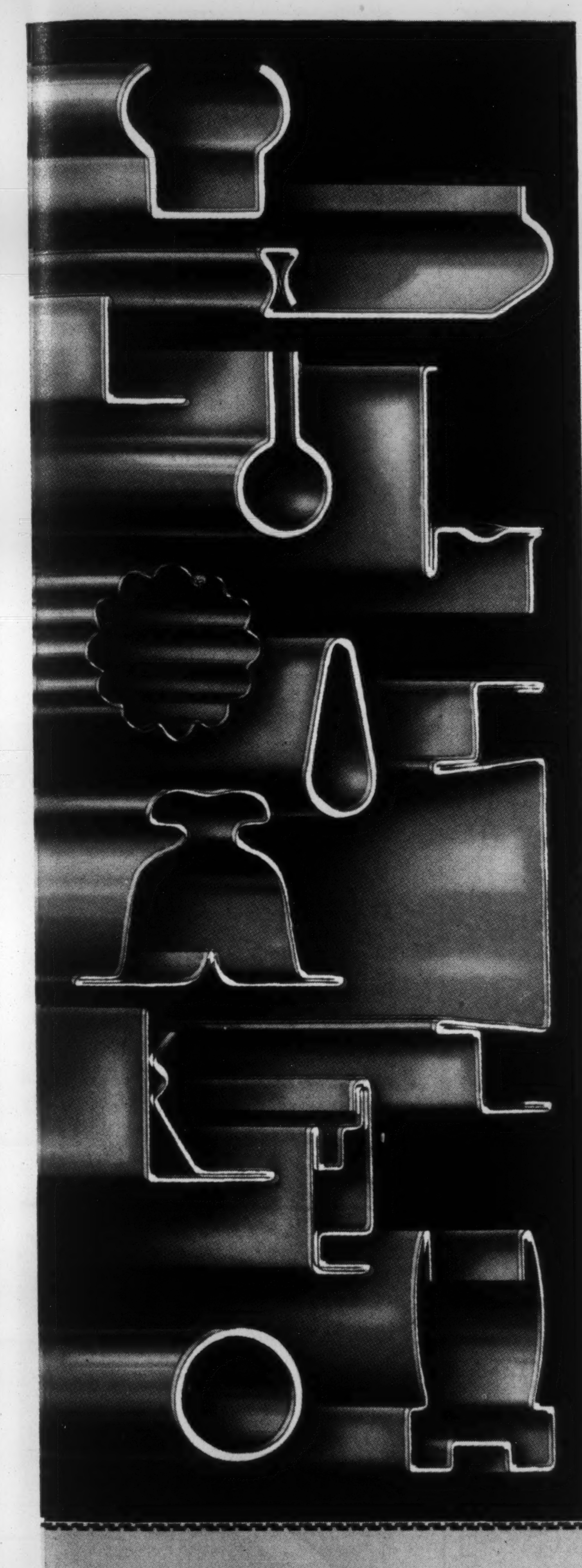
GE's varnish

One company, General Electric Co., Schenectady 5, N. Y., calls its varnish Alkanex and says it has twice the heat resistance of competitively-priced materials. GE says its Class F varnish is expected to be priced at less than half the cost of insulating varnishes used in the next higher rated Class H system (355 F) and only slightly more than those used in the lower Class B system (270-310 F).

GE's specially modified polyester varnish is reported to cure at 250 F to a tough, flexible film with good adhesive and electrical properties, and good resistance to oil, moisture and acids. The company says its varnish is compatible with most materials found in electrical equipment and is supplied in a solvent that will not cause excessive swelling of most types of silicone rubber leads.

Enamel and varnish

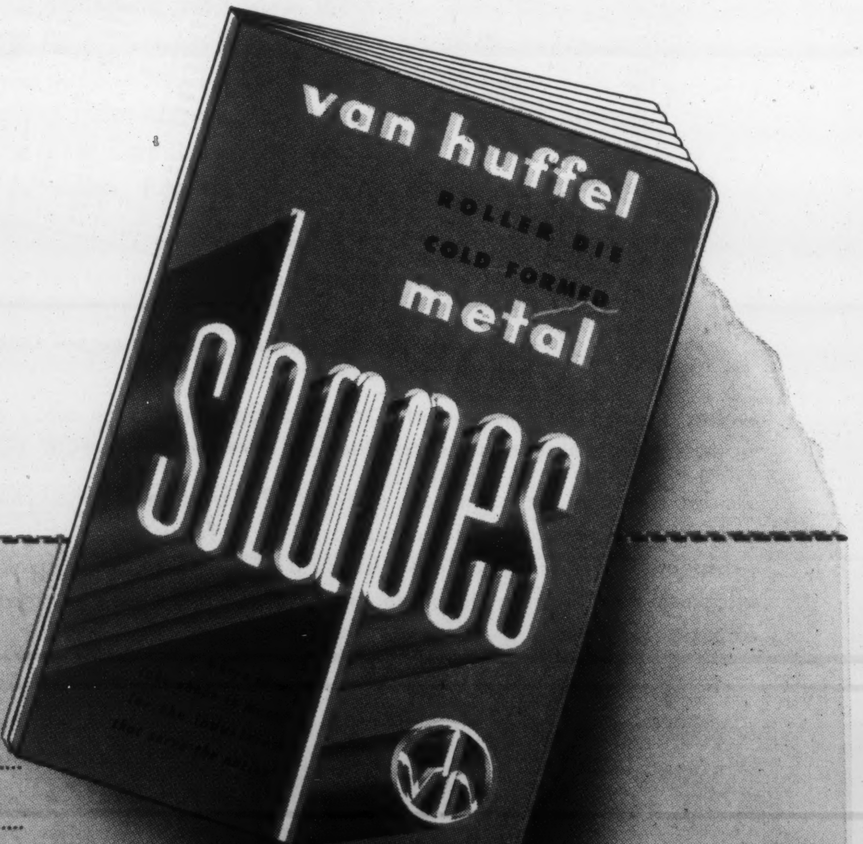
The other company to introduce a Class F varnish is Schenectady Varnish Co., Inc., Schenectady, N. Y. Schenectady engineers say their varnish and wire enamel system withstands hot spot temperatures of 355 F, yet can be applied and cured at conventional curing temperatures of around 250 F. Designated as Isonel No. 175 wire enamel and Isonel No. 31



if your product is made of metal YOU NEED THIS BOOK

In this 48 page handbook you'll find useful engineering and fabricating data including practical examples showing where, when and how Van Huffel Roller Die, Cold Formed Metal Shapes simplify design, increase production and reduce costs. It includes information on material selection, machine operations on shapes, fabrication methods, tolerances for roll forming, and dozens of interesting illustrated ideas that have taken shape in metal.

To get your free copy of this valuable handbook, mail the coupon today.



VAN HUFFEL TUBE CORPORATION
Warren, Ohio
Please send a copy of your Metal Shape Handbook

Name and Title...

Company...

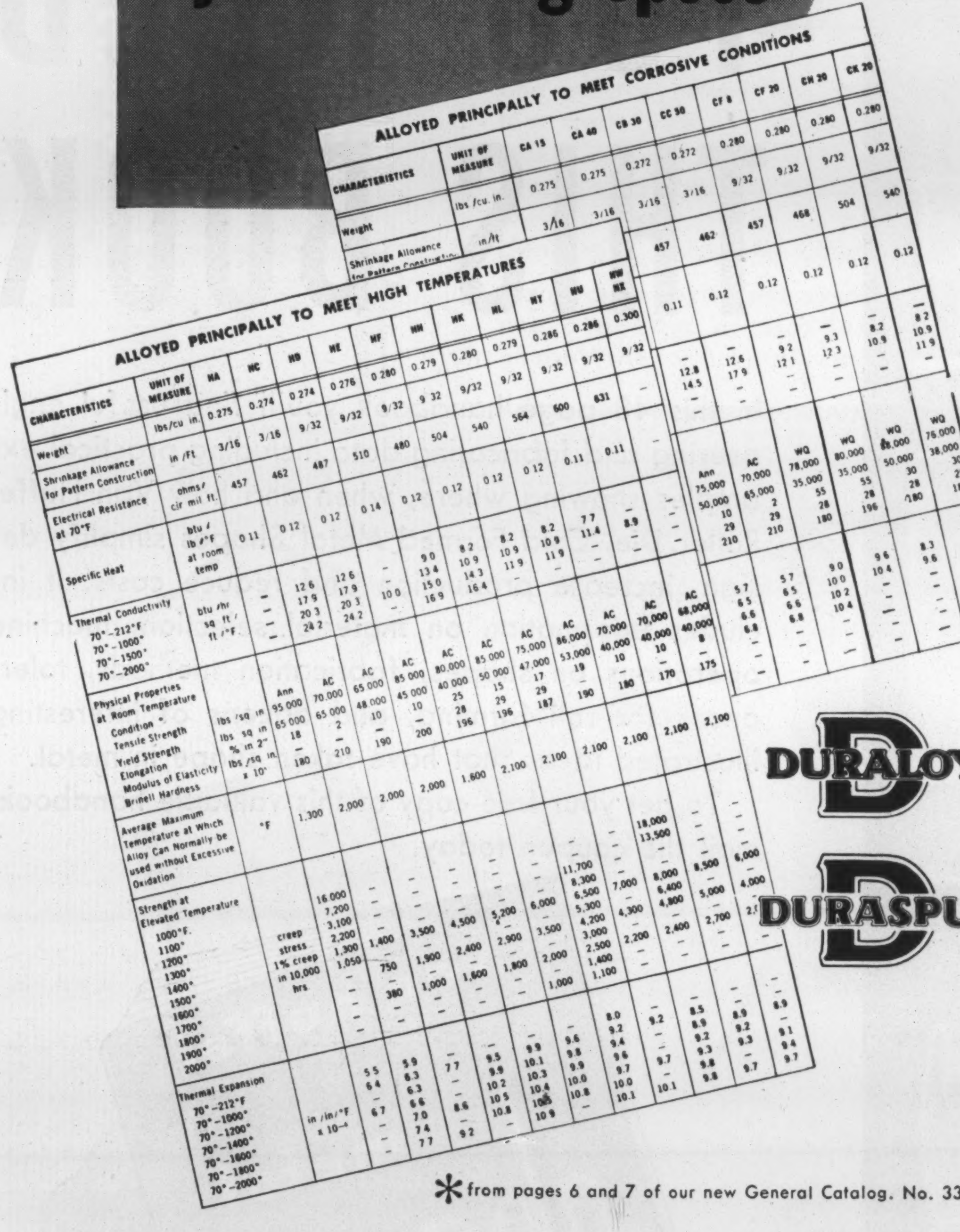
Address...

City.. **State**..............................

For more information, turn to Reader Service card, circle No. 483

TABLES

to help you select the proper alloy for your casting specs



ALLOYED PRINCIPALLY TO MEET CORROSIVE CONDITIONS

CHARACTERISTICS	UNIT OF MEASURE	CA 15	CA 40	CB 30	CC 50	CF 8	CF 20	CH 20	CK 20
Weight	lbs/cu. in.	0.275	0.275	0.272	0.272	0.280	0.280	0.280	0.280
Shrinkage Allowance for Pattern Construction	in/ft	3/16	3/16	3/16	3/16	9/32	9/32	9/32	9/32
				457	462	457	468	504	540
				0.11	0.12	0.12	0.12	0.12	0.12
				– 12.8 14.5 –	– 12.6 17.9 –	9.2 12.1 – –	– 9.3 12.3 – –	– 8.2 10.9 – –	– 8.2 10.9 11.9 –
				Ann 75,000 50,000 10 29 210	AC 70,000 65,000 2 29 210	WQ 78,000 35,000 55 28 180	WQ 80,000 35,000 55 28 196	WQ 88,000 50,000 30 28 180	WQ 76,000 38,000 30 29 180
				5.7 6.5 6.6 6.8 – – –	5.7 6.5 6.6 6.8 – – –	9.0 10.0 10.2 10.4 – – –	9.6 10.4 – – – –	8.3 9.6 – – – –	8.0 9.2 9.4 9.6 9.7 10.0 10.1

ALLOYED PRINCIPALLY TO MEET HIGH TEMPERATURES

CHARACTERISTICS	UNIT OF MEASURE	HA	HC	HD	HE	HF	HH	HK	HL	HT	HU	HW HX
Weight	lbs/cu in.	0.275	0.274	0.274	0.276	0.280	0.279	0.280	0.279	0.286	0.286	0.300
Shrinkage Allowance for Pattern Construction	in/Ft	3/16	3/16	9/32	9/32	9/32	9 32	9/32	9/32	9/32	9/32	9/32
Electrical Resistance at 70°F	ohms/cir mil ft.	457	462	487	510	480	504	540	564	600	631	–
Specific Heat	btu/lb/°F at room temp	0.11	0.12	0.12	0.14	0.12	0.12	0.12	0.12	0.11	0.11	–
Thermal Conductivity 70°–212°F 70°–1000° 70°–1500° 70°–2000°	btu/hr sq ft/ft/°F	– – – –	12.6 17.9 20.3 24.2	12.6 17.9 20.3 24.2	– – 10.0 –	9.0 13.4 15.0 16.9	8.2 10.9 14.3 16.4	8.2 10.9 11.9 –	8.2 10.9 11.9 –	7.7 11.4 – –	– 8.9 – –	– – – –
Physical Properties at Room Temperature Condition * Tensile Strength Yield Strength Elongation Modulus of Elasticity Brinell Hardness	lbs/sq in lbs sq in % in 2" lbs/sq in. x 10^6	Ann 95 000 65 000 18 – 180	AC 70.000 65 000 2 – 210	AC 65 000 48 000 10 – 190	AC 85 000 45 000 10 – 200	AC 80,000 40 000 25 28 196	AC 85 000 50 000 15 29 196	AC 75,000 47,000 17 29 187	AC 86,000 53,000 19 – 190	AC 70,000 40,000 10 – 180	AC 70,000 40,000 10 – 170	AC 68,000 40,000 8 – 175
Average Maximum Temperature at Which Alloy Can Normally be used without Excessive Oxidation	°F	1,300	2,000	2,000	2,000	1,600	2,100	2,100	2,100	2,100	2,100	2,100
Strength at Elevated Temperature 1000°F. 1100° 1200° 1300° 1400° 1500° 1600° 1700° 1800° 1900° 2000°	creep stress 1% creep in 10,000 hrs.	16,000 7,200 3,100 2,200 1,300 1,050 – – – – –	– – – – 1,400 – 750 – 380 – –	– – – – 3,500 – 1,900 – 1,000 – –	– – – – 4,500 – 2,400 – 1,600 – –	– – – – 5,200 – 2,900 – 1,800 – –	– – – – 6,000 – 3,500 – 2,000 – 1,000	– – 11,700 8,300 6,500 5,300 4,200 3,000 2,500 1,400 1,100	– – – – 7,000 – 4,300 – 2,200 – –	18,000 13,500 – – 8,000 6,400 4,800 – 2,400 – –	– – – – 8,500 – 5,000 – 2,700 – –	– – – – 6,000 – 4,000 – 2, –
Thermal Expansion 70°–212°F 70°–1000° 70°–1200° 70°–1400° 70°–1600° 70°–1800° 70°–2000°	in/in/°F x 10^{-6}	5.5 6.4 – 6.7 – – –	5.9 6.3 6.3 6.6 7.0 7.4 7.7	– 7.7 – – 8.6 – 9.2	– 9.5 9.9 10.2 10.5 10.8 –	– 9.9 10.1 10.3 10.4 10.5 10.9	– 9.6 9.8 9.9 10.0 10.8 –	8.0 9.2 9.4 9.6 9.7 10.0 10.1	– 9.2 – – 9.7 – 10.1	– 8.5 8.9 9.2 9.3 9.8 9.8	– – 8.9 9.2 9.3 – 9.7	– – 8.9 – 9.1 9.4 9.7

DURALOY

DURASPUN

* from pages 6 and 7 of our new General Catalog. No. 3354-G

— and there's lots more useful information about high alloy castings in our up-to-date catalog describing Duraloy Service. SEND FOR YOUR COPY.

As one of the pioneers in both static (1922) and centrifugal (1931) high alloy castings, we have a wealth of experience to focus on your high alloy casting problem. Send for our catalog, study it, and then let us help you get the best alloying combination to solve your corrosion, high temperature and/or abrasion problem.

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DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

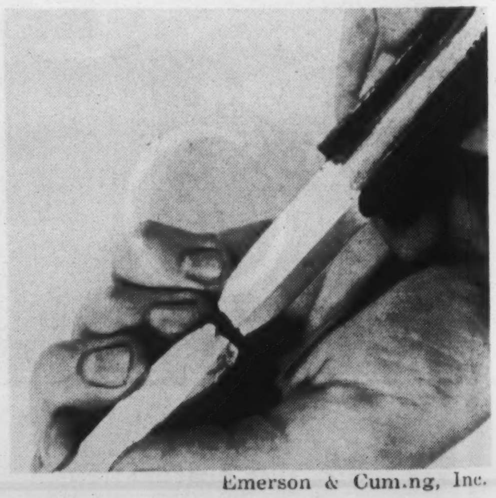
For more information, turn to Reader Service card, circle No. 401

insulating varnish, the insulation is said to provide a substantial safety margin when used in Class A, Class B or Class F applications. Results of accelerated heat aging tests indicate that twisted pairs of magnet wire enameled with Isonel No. 175 enamel, then coated with Isonel No. 31 varnish and exposed to a Class H temperature (355 F), have a life expectancy of 30,000 hr.

Because of their good heat resistance, the two polyester varnishes and the polyester enamel should be well suited for use in motors and generators operating at high speeds and high temperatures.

Galvanized Angles

A line of galvanized steel angles in all bar sizes is now being stocked by Rolled Steel Corp., Skokie, Ill. According to the supplier, angles are usually custom galvanized and not normally



Emerson & Cuming, Inc.

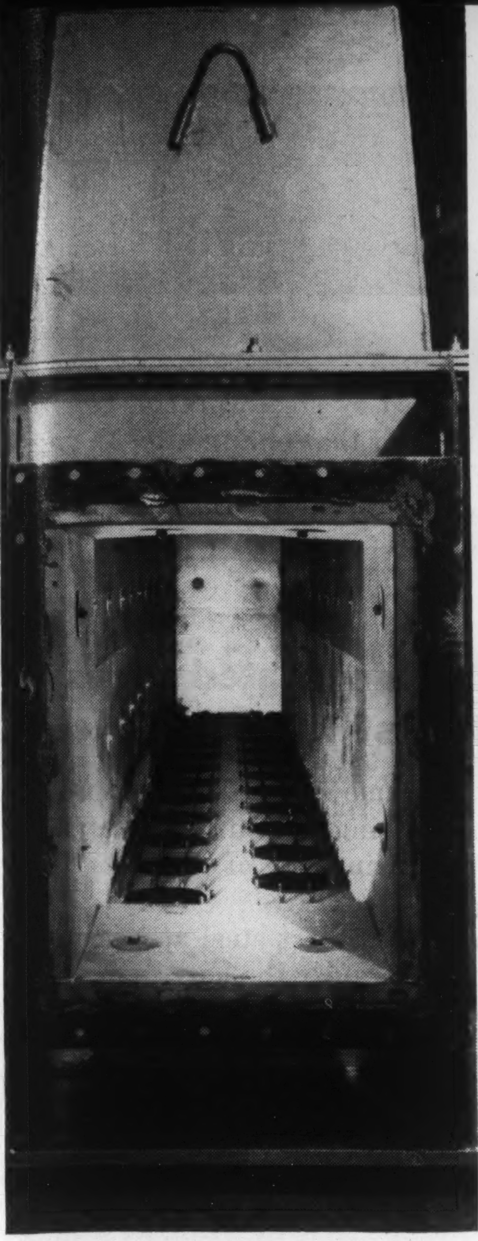
Strong bond—A one part epoxy adhesive that requires only heat to cure bonds a steel plate to an aluminum bar for use in a large generator. After the assembly is aged 1000 hr at 300 F the aluminum bar fails in tension as shown but the epoxy adhesive still holds the steel plate to the bar.

For more information, circle No. 462 ➤

NOTHING can equal Stainless Steel

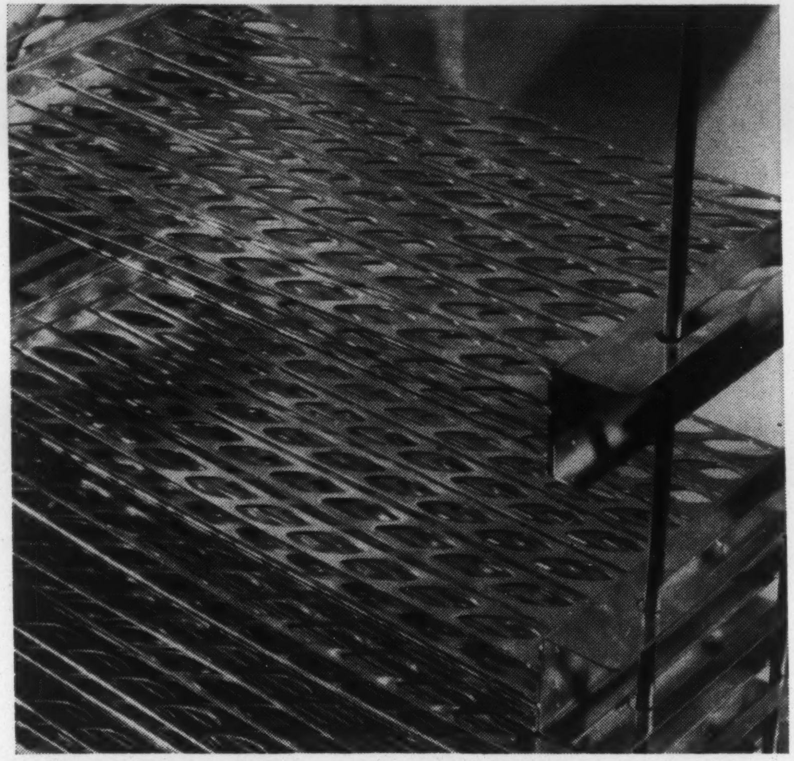
in its unique combination of properties

No other design material can match Stainless Steel in its combination of desirable properties: corrosion resistance, strength, hardness, beauty, cleanability and easy fabrication. For a reliable source of supply, United States Steel offers you the widest range of types, finishes and sizes. **Just call your steel warehouse.**



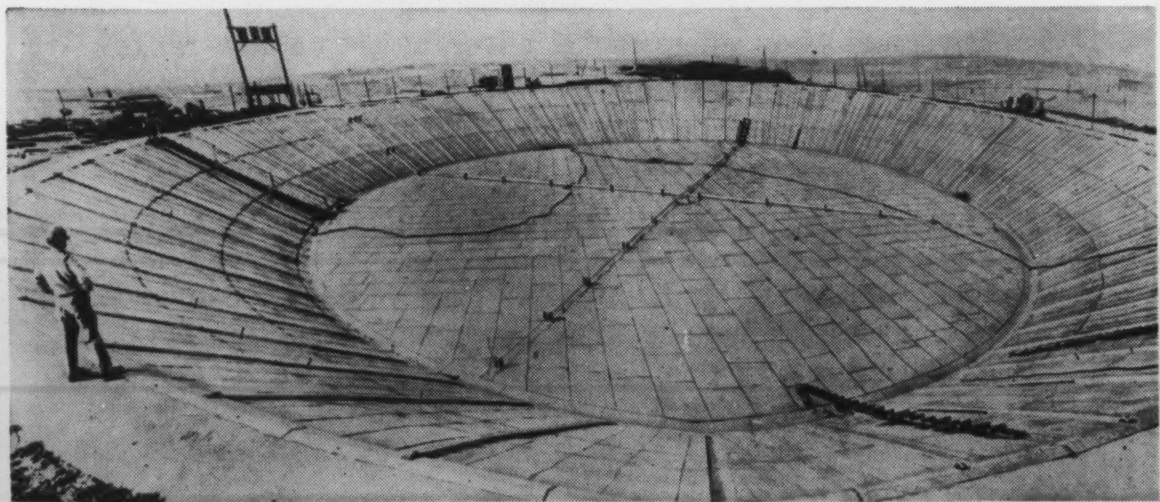
For High Temperatures. This recuperator is used on industrial furnaces. It uses waste flue gas to heat the incoming furnace air and thereby increase the efficiency of the furnace. Formerly, these recuperators were made with ceramic tubes, but heat transfer was low and leakage was high. The Hazen Engineering Company in Pittsburgh makes recuperators almost completely from Stainless Steel. Compared to ceramic designs, the Stainless design saves about 40% in fuel, increases furnace output about 10%-15%. The Stainless Steel performs well, even at this 1800-2300° F. temperature range.

For Corrosion Resistance. The Hercules Powder Company needed an ammonium nitrate storage tank for their plant near Richmond, California. They took an old, World War I concrete reservoir and lined it with Type 304 USS Stainless Steel. The 14-gage sheets are laced with 18,000 feet of vacuum-tested welds. Tank holds two million gallons of solution, and is 200 feet in diameter at the top. U. S. Steel's Consolidated Western Division handled the complete installation.



For Cleanliness. When you work near nuclear radiation areas, you wear a small badge containing X-ray film that records how much radiation you have received. The film, "photodosimetric film," is developed in a Sensitometric Processing Unit made by Bar-Ray Products, Inc., in Brooklyn. The unit, including the trays shown here, is made completely from 18-gage Type 316 Stainless Steel because it resists corrosion, is easy to clean, has a hard, dense surface that doesn't harbor dirt.

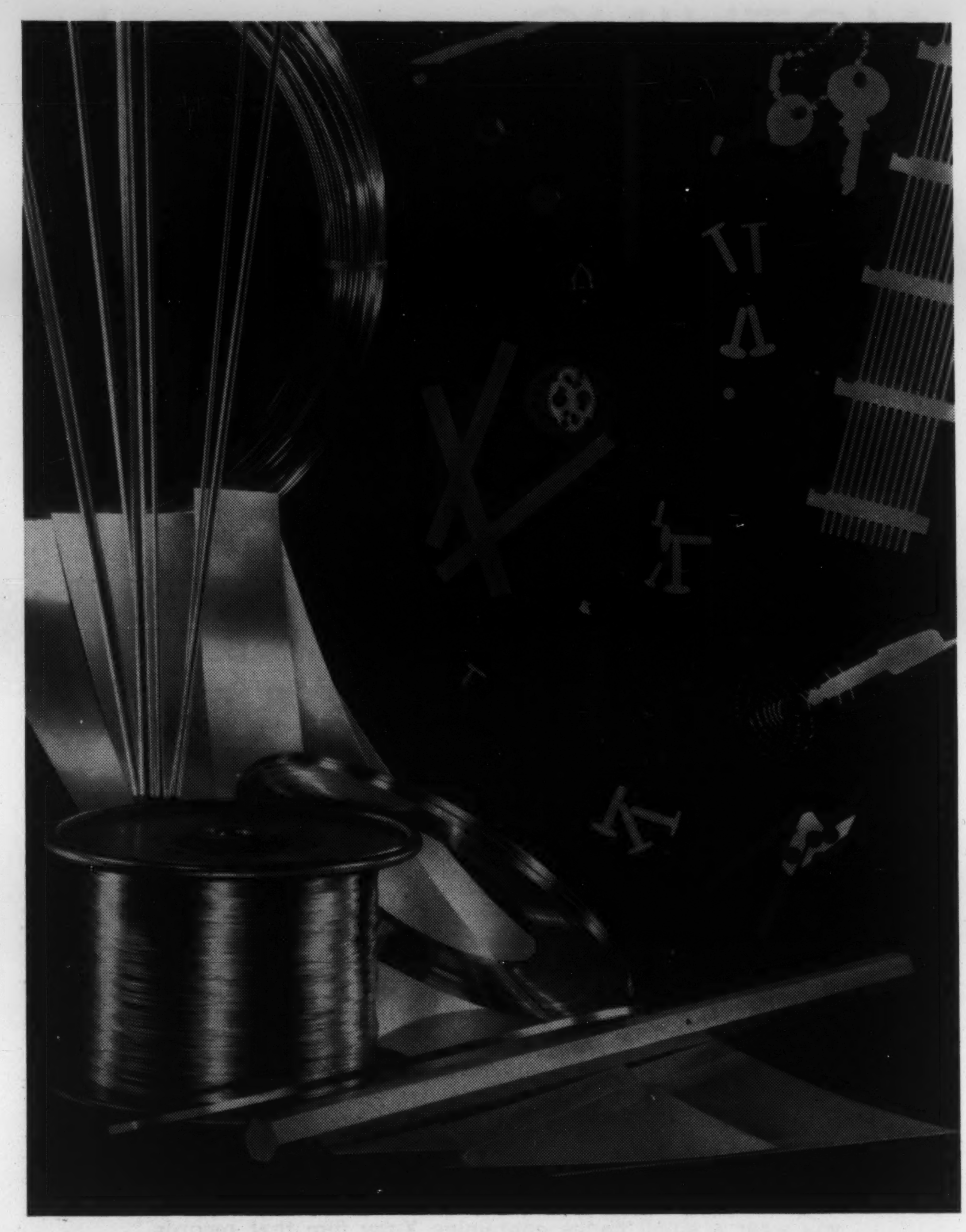
United States Steel Corporation, Pittsburgh · American Steel & Wire Division, Cleveland
Columbia-Geneva Steel Division, San Francisco · National Tube Division, Pittsburgh
Tennessee Coal & Iron Division, Fairfield, Ala.
United States Steel Supply Division, Warehouse Distributors
United States Steel Export Company, New York



USS STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

UNITED STATES STEEL



PUT MORE SELL IN YOUR PRODUCT
with Riverside-Alloy nickel silver

Riverside-Alloy nickel silver can help you make a more saleable product in two ways. First, by giving it a lustrous, lasting, "clear-through" *outside* beauty that will never wear away. Second, by giving it astonishing *inner strength*, with resistance to wear, corrosion and fatigue.

Riverside-Alloy offers nickel silver in a complete range of alloys, tempers, and anneals that can be soft-soldered, silver brazed, and spot and arc welded with ease.

Let Riverside-Alloy technicians work closely with your engineers to choose just the right alloy for your product and problem from a wide selection of strips, wires, and rods. For more details on applications, and the name of your nearest Riverside-Alloy representative, write, wire, or call collect, *Riverside-Alloy Metal Division, H. K. Porter Company, Inc., Riverside, N.J.*

H. K. PORTER COMPANY, INC.
RIVERSIDE-ALLOY METAL DIVISION

For more information, turn to Reader Service card, circle No. 536

stocked by steel warehouses. It is believed that eliminating the need for galvanizing individual orders will substantially reduce the cost of the angles.

Boride Coated Parts Resist Hot Aluminum

A flame sprayed chromium boride coating, introduced recently by Metallizing Co. of America, 3520 W. Carroll Ave., Chicago 24, is said to protect steel and cast iron parts against the corrosive attack of liquid aluminum. The boride coating, called Borocote, is reported to have good wear and oxidation resistance, as well as good thermal conductivity and good dimensional stability. It has a melting point of 3750 F, a Rockwell C hardness of 65 and a density of 0.22 lb per cu in.

The coating is recommended for the protection of thermocouple tubes, wheels and pulleys, transfer troughs and atomizing nozzles that come in contact with liquid aluminum.

Expanded Metal Sheet Made in New Pattern

Expanded metal sheets measuring 2 x 4 ft are available from Penn Metal Co., 40 Central St., Boston in a new pattern. The new product, called Multimesh, has three different diamond sizes recurring in a regular pattern throughout the sheet. According to the company, this is a departure from customary patterns in which all diamonds in a sheet are the same size.

The expanded metal sheet is supplied in 22, 24, and 26-gage carbon steel and in 0.032-in. aluminum sheets. Strand widths are available in five different sizes: 0.034, 0.040, 0.060, 0.070 and 0.090 in. As the strand width increases

WHY YALE WAS CHOSEN TO MAKE THIS POWDERED METAL PART:

It's a very important part. Larger than most powdered metal parts. Helps run one of America's top-selling home appliances.

The appliance manufacturer surveyed the entire powdered metal industry before choosing YALE* to produce this part.

He knew that powdered metal parts cost far less than the machined parts they replace, but that wasn't enough. He had to be sure this savings in cost would be accomplished with no sacrifice in quality. That's why he chose YALE to produce this powdered metal part.

He had to be sure the millionth part would be as accurate as the first. That he'd get imaginative engineering. Large-scale production facilities. Delivery on schedule. More reasons why he came to YALE. And then there was one other fact he'd know from the very beginning...he knew he could depend on YALE. And he knows that you can, too. Our engineers are at your service whenever you'd like more information.

*REG. U.S. PAT. OFF.

sector gear shown about twice actual size

powdered metal parts

YALE & TOWNE

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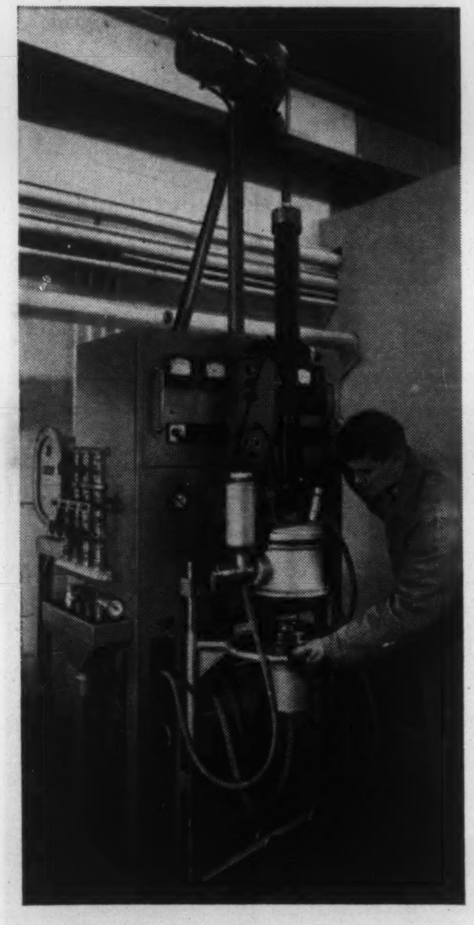
Cr, Hf, Ir, Mo, Nb, Os, Pd,
Pt, Re, Ta, Ti, V, W, Zr

Get pure vacuum melts of these metals

in minutes!



The Heraeus Vacuum Arc Melting Furnace Model VA-L200C, smallest of a line of Heraeus Furnaces sold by CEC.

With this new Heraeus Arc Melting Vacuum Furnace, the VA-L200C, you can get vacuum melts in "buttons" or ingots.

You can get them of Titanium, Zirconium, Tungsten, and other metals or alloys with high melting temperatures. You can get them fast and pure.

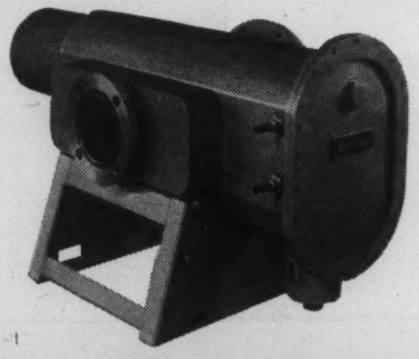
Super-fast mechanical pump—A Roots mechanical vacuum pump pulls pressures in the furnace down to 5 x 10^{-4}mm Hg—*fast*.

Its throughput of 10,400 micron CFM at 10 microns easily handles sudden gas bursts encountered with certain metals.

No oil contamination—The Roots pump's frictionless rotary pistons require no oil sealing. There can be no contamination from backstreaming vapors in the system.

No crucible contamination—The Heraeus furnace has a water-cooled, copper crucible which cannot contaminate the melt.

Fixed or consumable electrodes—You may use either fixed electrodes of tungsten or metallic carbides, or consumable electrodes of the metal you are melting.



This Roots pump maintains low, vapor-free pressures. A motor *operating within the vacuum* drives its rotary frictionless pistons.

This Heraeus furnace has many other features valuable in laboratory or small-scale production, including exceptional economy—operating either under vacuum or with an inert gas atmosphere.

Heraeus of Hanau, Germany, has licensed CEC as exclusive agent for Heraeus Arc Furnaces (and Roots Pumps) in this country. Complete details in our Bulletins P8-20 and P4-28.

Consolidated Electrodynamics
Rochester Division, Rochester 3, N. Y.
formerly Consolidated Vacuum

SALES AND SERVICE OFFICES IN PRINCIPAL CITIES

For more information, turn to Reader Service card, circle No. 450

the percentage of open area of the sheet decreases, ranging from approximately 60% open area for strand widths of 0.034 in. to 16% for strand widths of 0.090 in.

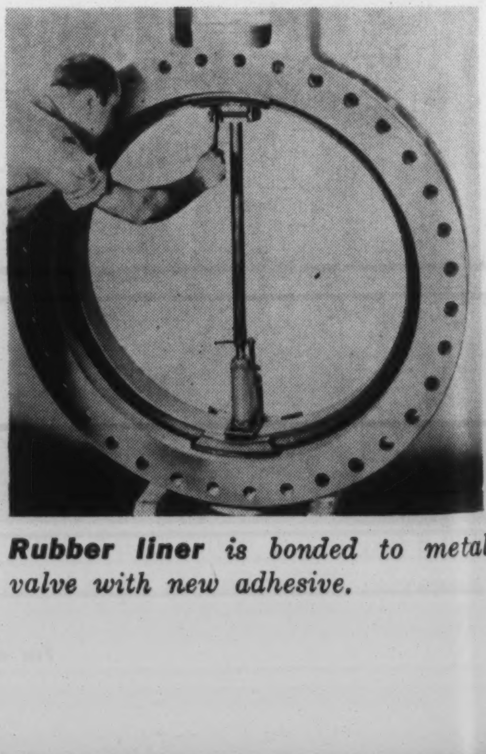
Other gages in steel and aluminum, as well as other metals such as monel, copper and brass, are available on special order.

Adhesive for Rubber Has High Strength

A new adhesive for bonding cured natural and synthetic rubber to metal is said to provide a bond so strong that the rubber will tear before it can be peeled from the metal. The adhesive has a tensile strength of 2250 psi and a dielectric strength of 400 to 450 v per mil.

Developed by Raybestos-Manhattan, Inc., Adhesives Dept., Bridgeport 2, Conn., the bonding material, called Ray Bond R-86001, is a two component adhesive consisting of a synthetic resin base and an activator. The adhesive reaches a maximum strength after a 4-hr cure at 120 to 140 F. According to the producer, seven-day immersion tests in 10% hydrochloric acid, 3% sulfuric acid, 10% ammonium hydroxide and 10% sodium hydroxide show no visible effect on the bond.

In addition to bonding natural



Rubber liner *is bonded to metal valve with new adhesive.*

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At Northwest our "special branch of activity" is solving your cleaning problems.

Behind your friendly, competent Northwest Sales Engineer stands a reputation for providing industry with low-cost, analytically-correct, job-adjusted chemical cleaners.

From Northwest's years of experience in formulating the RIGHT cleaner for your specific needs have come such developments as the LO-HI pH PROCESS—for cleaning prior to plating, painting, or vitreous enameling; ALKALUME PROCESS—for preparing aluminum and magnesium for finishing and spot welding; INTERLOX PROCESS—for phosphate coating; SPRA-LUBE—to control over-spray of "today's" paints in water wash paint booths; PAINT STRIPPERS—specific to your needs; SUPER-DRAW & FLUID FILM—for drawing metals.

Northwest products are manufactured on the west coast by—

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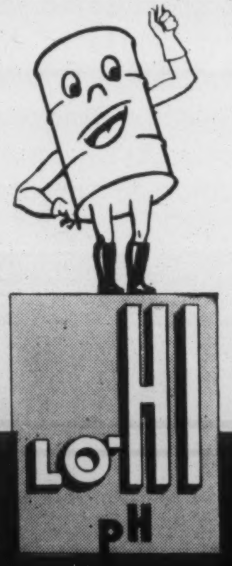
Remember—YOUR COST PER FINISHED ARTICLE IS THE TRUE COST OF YOUR CLEANER.

Northwest's production-tested chemicals and "Right the first time" recommendations will save you money. Northwest Service is as close as your phone.



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Non-Contaminating!
Self-Lubricating!
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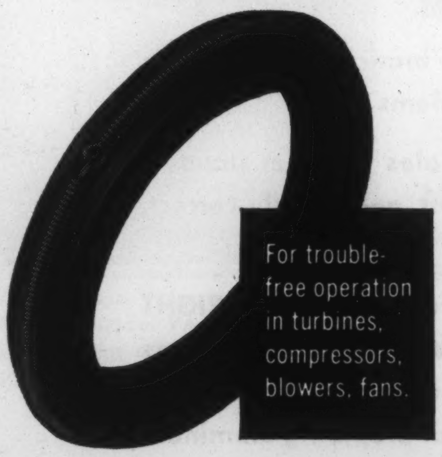
SELF-LUBRICATING
CARBON PISTON RINGS and ROD PACKINGS
. . . for non-lubricated compressors

Eliminates lubrication problems in compressors where contamination cannot be tolerated. The inherent lubricating property of Morganite, plus ability to polish and glaze compensating surfaces, assure friction minimizing operation. A corrosion resistant film imparted to opposing metal surfaces prevents scoring . . . reduces maintenance and replacement.

CARBON GLAND RINGS
. . . for high sealing efficiency

These high efficiency pressure and vacuum seals for steam turbines can be safely mounted with less clearance than metallic rings. Unaffected by axial movement of shaft, accommodate considerable radial shaft displacement with no danger of seizure or loss of efficiency.



For trouble-free operation in turbines, compressors, blowers, fans.

Specify Morganite! For sealed mechanisms, inaccessible locations or where contamination is a problem—Morganite Self Lubricating Bearings, Valve Components, Slides, Seal Noses and Pump Vanes are available. Write for complete details and literature, now!

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Distributors of 99.7% Pure Al_2O_3 Tubes and Crucibles

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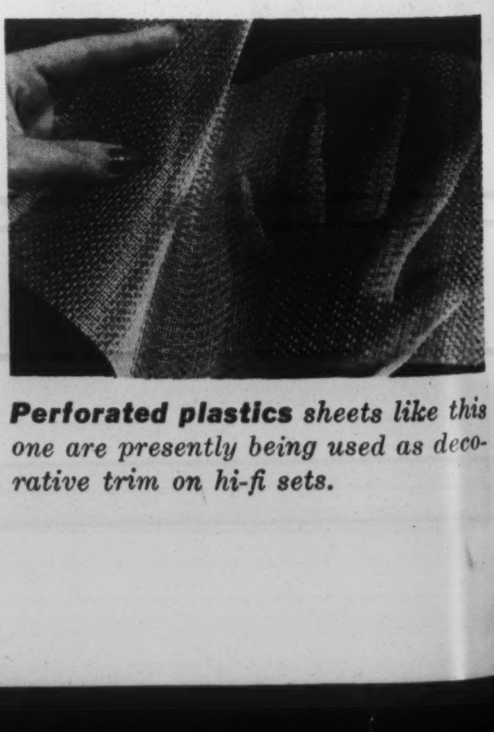
and synthetic rubber, Ray Bond R-86001 may be used to bond metal, glass, ceramics and wood to themselves and to other materials. The adhesive can also be used as a protective coating, and as a sealing and a casting compound.

Iron Alloy Castings Are Wear Resistant

Cast agitators, mixers, paddles, screw feeders and similar items made of a new iron-chromium alloy called "ZeVesCal" are said to outwear competitive materials "by as much as 13 to 1." Introduced by Calumet Steel Castings Corp., 1636 Summer St., Hammond, Ind., the cast alloy has a metallurgical structure of hard, complex carbides embedded in a matrix of unstable austenite. The alloy is sand cast, then air quenched. Castings made of the alloy are said to be exceptionally good for resisting the wear of powdered glass.

Decorative Trim

Gold, silver and copper colored embossed and perforated sheets of polyester film laminated to vinyl film are available as decorative trim from Coating Products, Inc., 101 W. Forest Ave., Englewood, N. J. According to the producer,



Perforated plastics *sheets like this one are presently being used as decorative trim on hi-fi sets.*

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with a

Cincinnati Hydrospin

Many of the conical, curvilinear, hemispherical and tubular shapes required for rocket and guided missile components can be—and are now being—"chipless machined" by a Cincinnati Hydrospin.®

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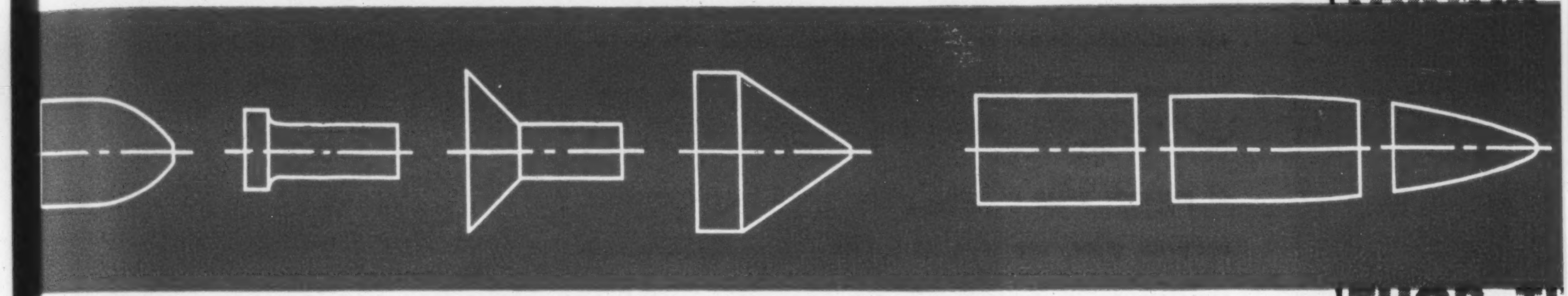

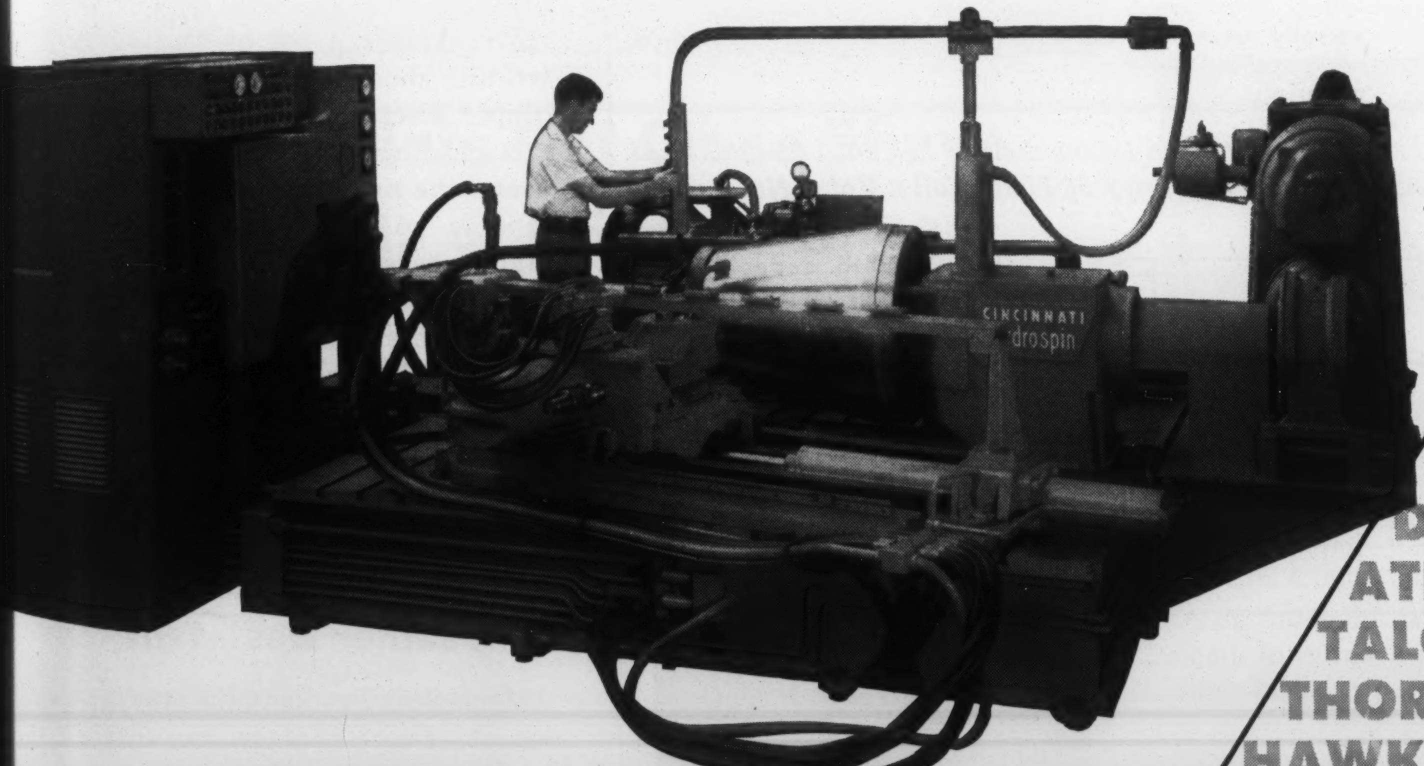
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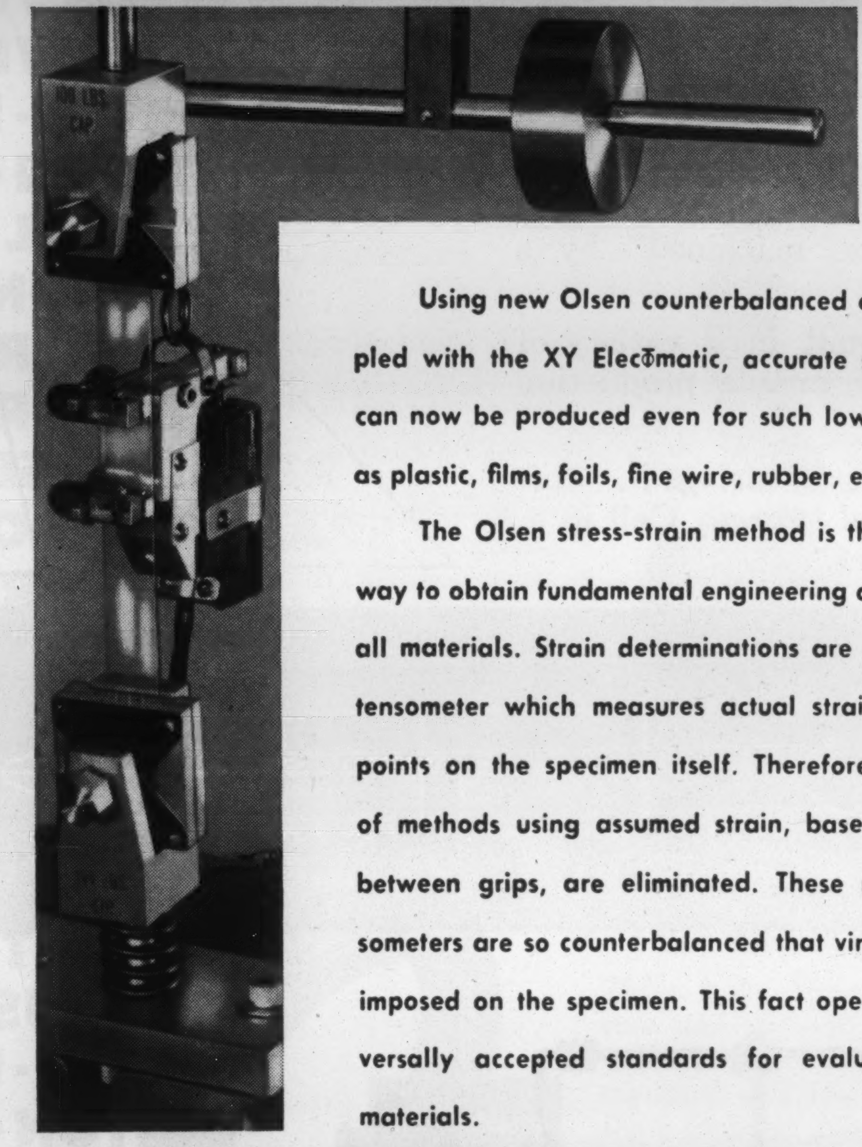
CINCINNATI 9, OHIO, U. S. A.

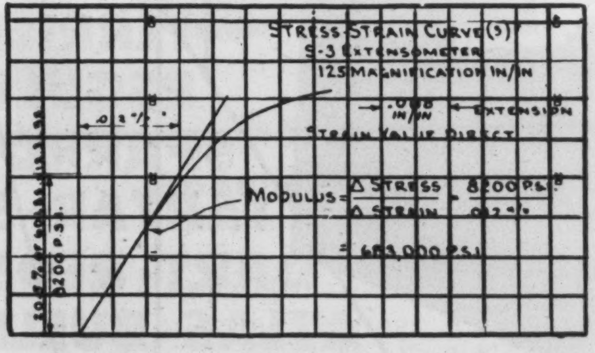
NOW! Accurate Stress-Strain Curves of Most Materials — Even Plastic Film



Using new Olsen counterbalanced extensometers coupled with the XY Elecōmatic, accurate stress-strain curves can now be produced even for such low tensile specimens as plastic, films, foils, fine wire, rubber, etc.

The Olsen stress-strain method is the reliable, proven way to obtain fundamental engineering data for practically all materials. Strain determinations are made with an extensometer which measures actual strain between gauge points on the specimen itself. Therefore, the inaccuracies of methods using assumed strain, based on the distance between grips, are eliminated. These new Olsen extensometers are so counterbalanced that virtually no weight is imposed on the specimen. This fact opens the way to universally accepted standards for evaluating low tensile materials.

A special report on this Olsen testing method has just been published. We invite you to write for a copy of Tinius Talks, Vol. 9 No. 1 today.



Accurate stress-strain curves of plastic films, as shown, are a matter of simple routine with the Olsen XY Elecōmatic.

This 12,000 lb. capacity XY Elecōmatic provides positive testing speeds and unlimited stroke plus all the flexibility of an XY Recorder.

Trademark
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TESTING MACHINE COMPANY
2010 EASTON ROAD • WILLOW GROVE, PA.
Testing and Balancing Machines

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the material is available in 27-in. wide rolls with 240 perforations per sq in.

Welded Steel Tubing Is Easy to Fabricate

Welded steel tubing produced by an ultra high frequency welding method are said to have particularly good fabricating qualities and cleaner inside surfaces than tubing produced from conventional resistance welding methods.

The ultra high frequency resistance method is being used by the Steel and Tubes Div. of Republic Steel Corp. to weld steel tubing in sizes from 1 to 3 in. o.d. and wall thicknesses from 0.050 to 0.100 in. The method, adapted from New Rochelle Tool Corp.'s "Thermatool" process, produces an edge surface weld and employs the electric resistance principle. It operates at frequencies of 450,000 cps and uses a set of stationary welding shoes instead of the usual copper electrodes.

According to Republic engineers, the new method has proved capable of producing tubes at high speeds with a high quality weld. Republic engineers also say a small internal welding bead can be obtained, thereby saving the customer the extra charges necessary for removing the flash.

Silicone-Epoxy Coating Is Weather Resistant

Mono-Seal Products Co., 44 Garden St., Everett, Mass. has introduced a protective coating formulated from a special blend of silicone and epoxy resins. According to the producer, the cured coating has good corrosion, impact, abrasion, weather and moisture resistance; it is also said to have good resistance to acids, alkalis, oils,

For more information, circle No. 490 ➤

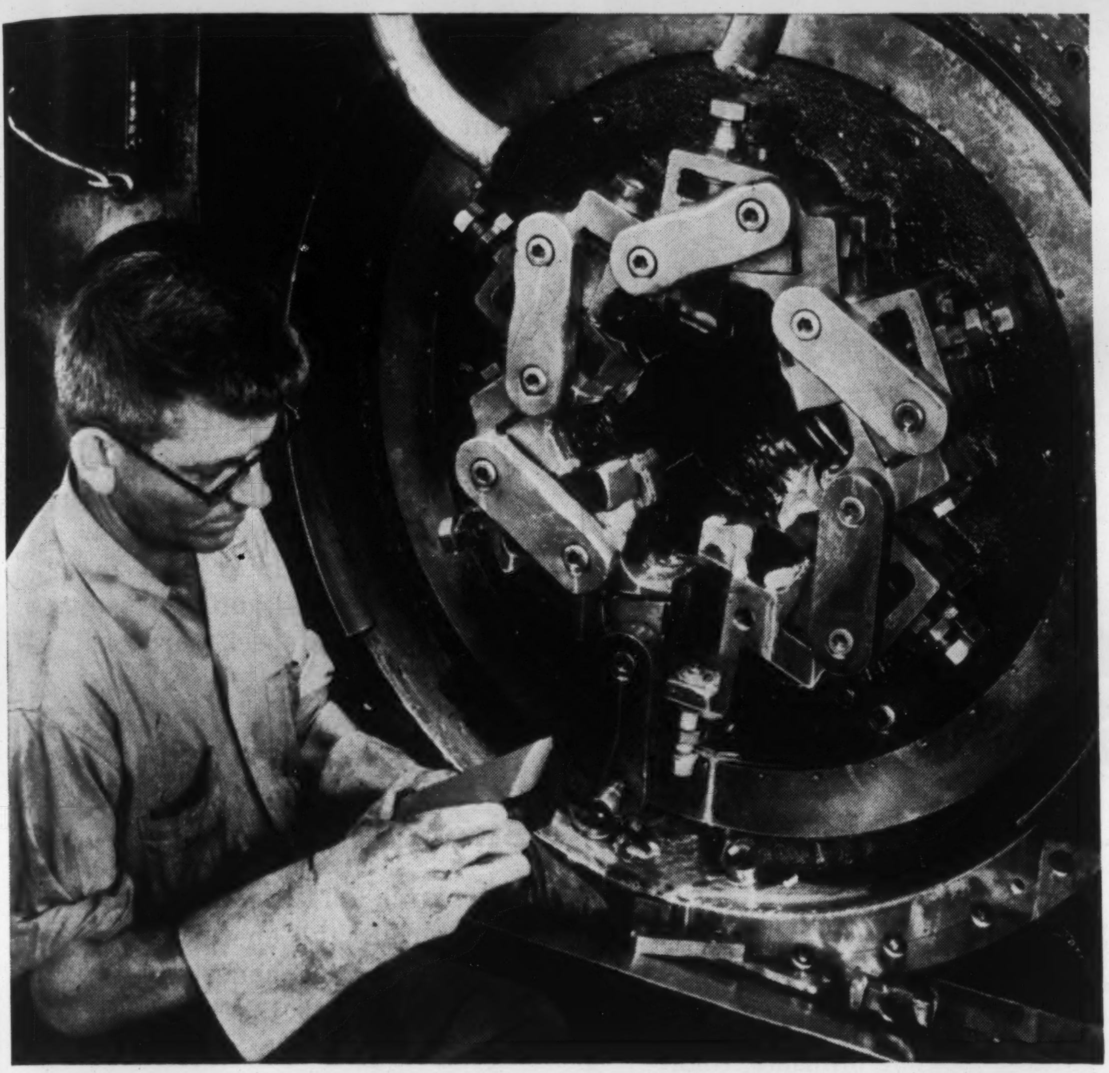
Tool Steel Topics

BETHLEHEM STEEL

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation



BETHLEHEM TOOL STEEL ENGINEER SAYS:

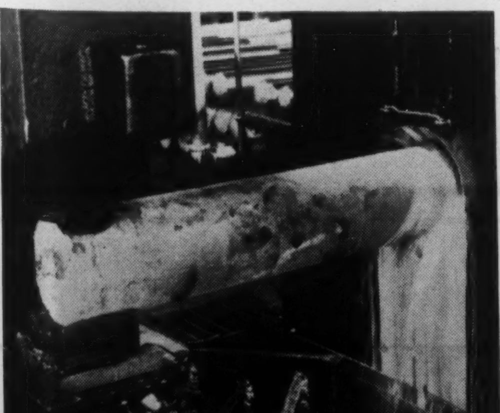
Overloading of Machines Shortens Tool Life

Overloading of machine tools is detrimental not only to the machines, but also to the life of the tools. Overloads cause excessive deflection of the constructional members, which may cause misalignment of mating tools and change calculated clearances. This in turn may produce excessive wear on the tools, and may result in defective parts or premature tool breakage.

Overloading frequently results from performing an excessive number of operations at one time, such as multiple piercing of holes. Overloads of this type can be prevented without changing the work to be done by providing, (1) shear on either the punch or die to reduce the maximum punching load, or, (2) by staggering punch heights so that the multiple operations are performed in sequence, instead of all at the same time.

Nickel Billets Get Close Shave with Tools of 66 High-Speed

Biting into billets, castings or forgings of nickel or nickel alloy is one of the toughest assignments ever devised for tool steel. And yet, such jobs are taken in stride with Bethlehem high-speed tool steel at the plant of International Nickel Co., Huntington, W. Va.

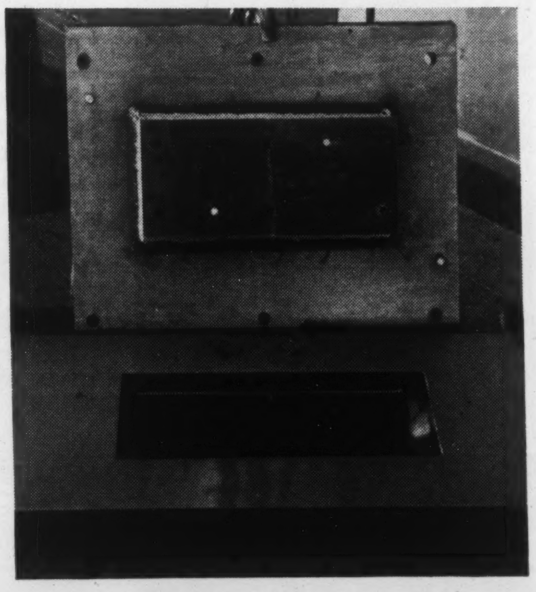


Bar peeler cutters, made of 66 High-Speed tool steel, prepare nickel surface for extrusion.

The bar peeler cutters, in the picture above, are hardened to Rockwell C 60-62, and are used in the surface preparation of nickel billets, prior to extrusion. Despite this extremely rugged operation, the cutters are doing an outstanding job, because of their unusual resistance to shock and wear.

66 High-Speed is ideal for all types of cutting applications because of its well-rounded 6-5-4-2 analysis. In addition to its outstanding shock and wear properties, it has excellent red-hardness and abrasion resistance — all the qualities needed for satisfactory high-speed cutting work.

If you would like to learn more about 66 High-Speed, and the many jobs it can handle, simply get in touch with your friendly Bethlehem tool steel distributor.



UP TO 30,000 CONVEYOR PANELS WITH DIE OF 67 CHISEL

This large blanking die was employed in the production of conveyor panels, made from 14-gage sheet steel. It was hardened to Rockwell C-50, and turned out as many as 30,000 pieces before redressing was required. 67 Chisel is our popular chrome-tungsten type of shock-resisting tool steel. In addition to its use in blanking, it's excellent for hot-work tools, shear blades, and swaging dies. Give it a try.

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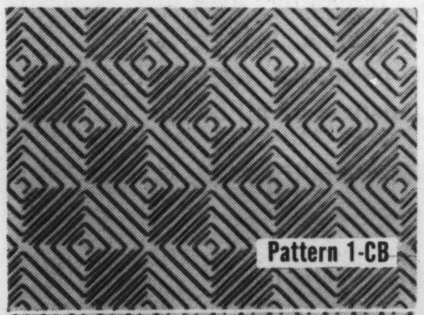
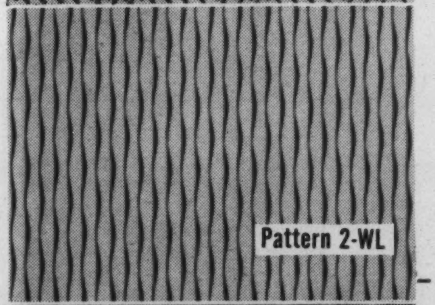
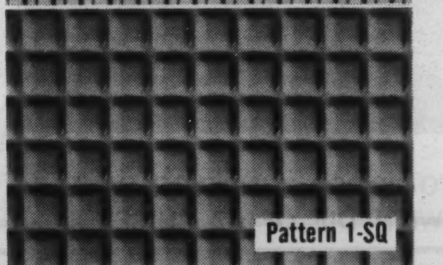
achieved by Good Design and

RIGID-tex METAL


Pattern 1-CB


Pattern 2-WL


Pattern 1-SQ

This pattern is used for the instrument panel and the door handwheel dome on Autoclave illustrated above.

The two go hand in hand. RIGID-tex Metal has texture that imparts sparkling brilliance; color that adds irridescent beauty!

Good design must also be practical. Here too, RIGID-tex Metal contributes with strength far greater than flat metal, greater yield and impact strength, greater rigidity... and even more than this... a mar-resistant surface that conceals scratches and smudges to provide a permanence of finish and beauty never before attained.

Let RIGID-tex Metal help you achieve more beautiful . . . more practical . . . more outstanding designs. There are over 40 standard patterns from which to choose — in all metals — all colors. Write for literature and samples today!

Tell me more about RIGID-tex Metal.

☐ Send a copy of "Pattern Selector" showing all the standard patterns.

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solvents, plasticizers, salty sea air and industrial atmospheres. Said to have a "natural stretch," the coating will not chip or peel when bent or dented.

The coating is recommended for machinery, tanks, trucks, boats, traffic lanes and equipment that is to be exposed to weathering. It contains no plasticizers or oils, curing by solvent evaporation and internal polymerization to a hard, glossy surface. The coating is supplied in a three part package containing a resin, an activator and a thinner, and is available as a glossy paint in clear and in 22 colors. Semigloss and flat paints are supplied on special order.

Microscope Reveals Strength of Steel

Research in the microstructure of materials at General Electric's laboratories in Schenectady, N. Y. has shown that the strength of steel can be directly related to the average distance between tiny carbide particles in the steel.

The scientists take a picture of the steel through an electron microscope, then measure the distance between the particles to gage the strength of the steel. They say that different tempering

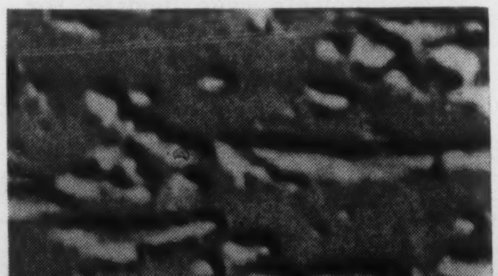

Fig 1—*Carbide particles shown in this photomicrograph of a piece of steel are about a millionth of an inch in diameter.*

The man from Olin Aluminum stands for a big Service Principle...

He offers you the unique advantage of Aluminum that is custom-tailored, from the start, to your exact requirements.

As salesman, field engineer or technical specialist, he brings to your service a personal reputation for integrity and experience in the Aluminum field. And behind him stands a flexible, compact organization skilled in a special Olin Mathieson Principle of swift, responsible and unwavering attention to every detail of your order.

He is ready to serve you now. Just call any of the offices listed below, or write:

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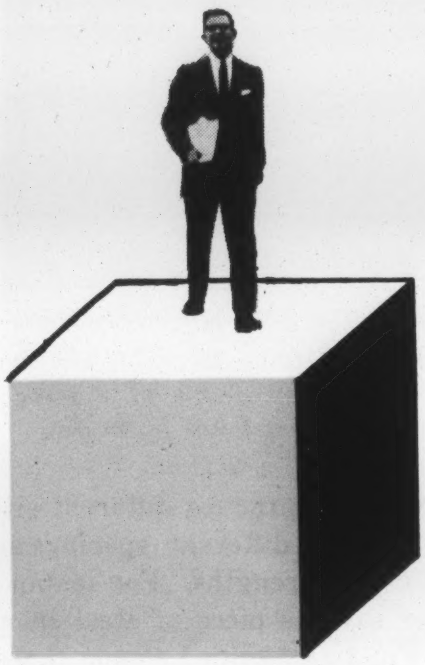

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OLIN ALUMINUM

Ω AND "OLIN ALUMINUM" ARE TRADEMARKS

Symbol of Quality and Service in the Aluminum industry

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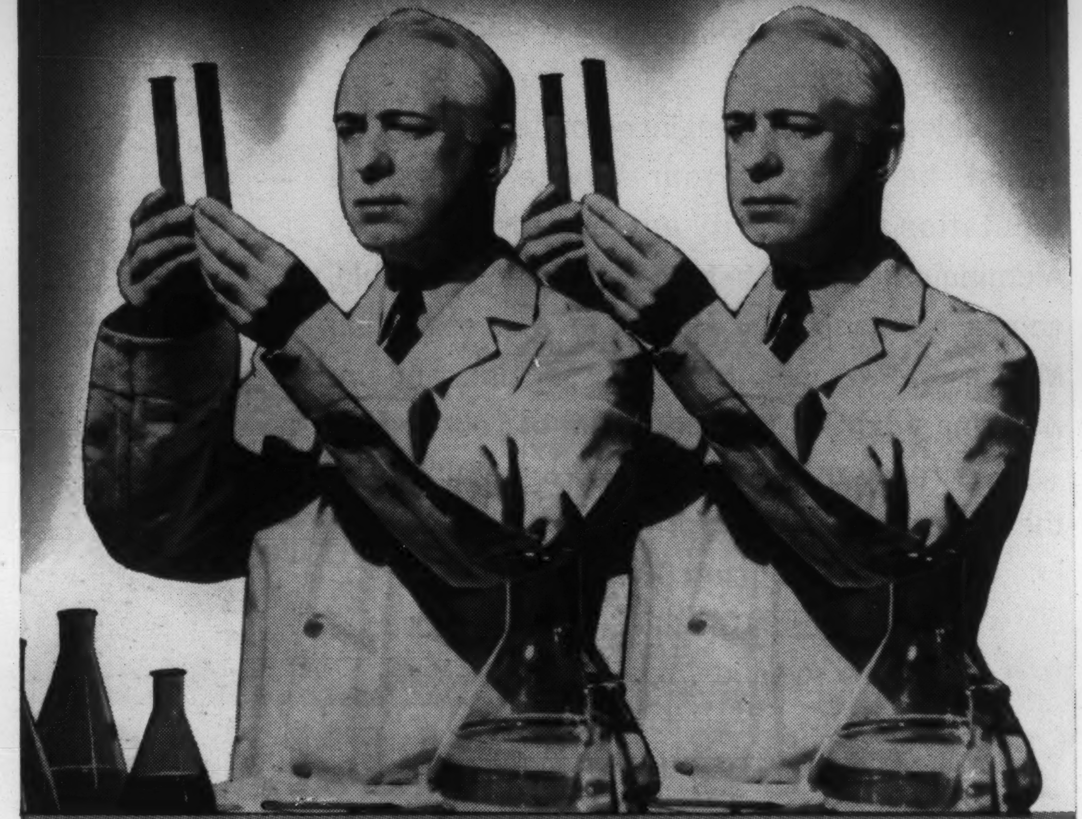
Only degreasing solvent with DUAL ACCEPTANCE



NEW DETREX

PERM-A-CLOR® (NA)

(TRICHLORETHYLENE)

Now, "Dual Acceptance" means greatly increased efficiency and economy for solvent degreasing operations because PERM-A-CLOR* NA contains acid acceptors that assure a new high degree of stabilization. Functioning in both the presence and absence of moisture, these acid acceptors also provide outstanding resistance to the widest range of industrial soils on any metal or combination of metals.

Through higher stability, PERM-A-CLOR* NA can be used, distilled and re-used while retaining full strength. The number of parts degreased per pound of solvent is greatly increased, while solvent loss is cut to a minimum. Costly down-time for maintenance is reduced because of PERM-A-CLOR's* remarkable, long-life stability.

Complete DETREX facilities include—degreasing solvents—alkali cleaners—emulsion cleaners—phosphate conversion coatings—degreasing equipment and industrial washers—Ultrasonic cleaning machines—unexcelled technical counsel and engineering field service.

*PERM-A-CLOR is the registered trademark of

DETREX CHEMICAL INDUSTRIES, INC.

BOX 501, DETROIT 32, MICHIGAN

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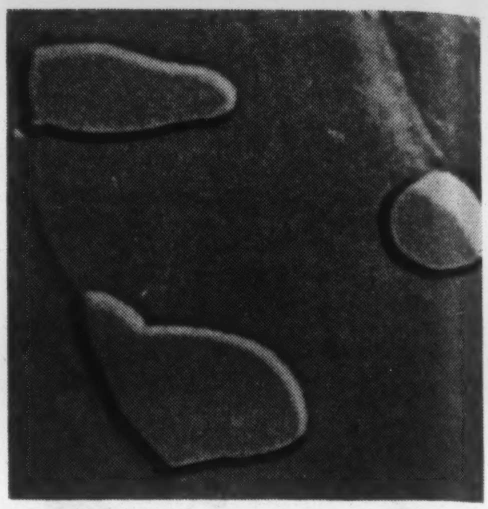


Fig 2—*Carbide particles shown in this photomicrograph of a piece of steel are about 0.030 in. in dia.*

techniques produce different sizes of particles, different spacings and different strengths. For instance, they say the piece of steel shown in Fig 1 (magnified 40,000 times) is 2½ times as strong as the steel shown in Fig 2.

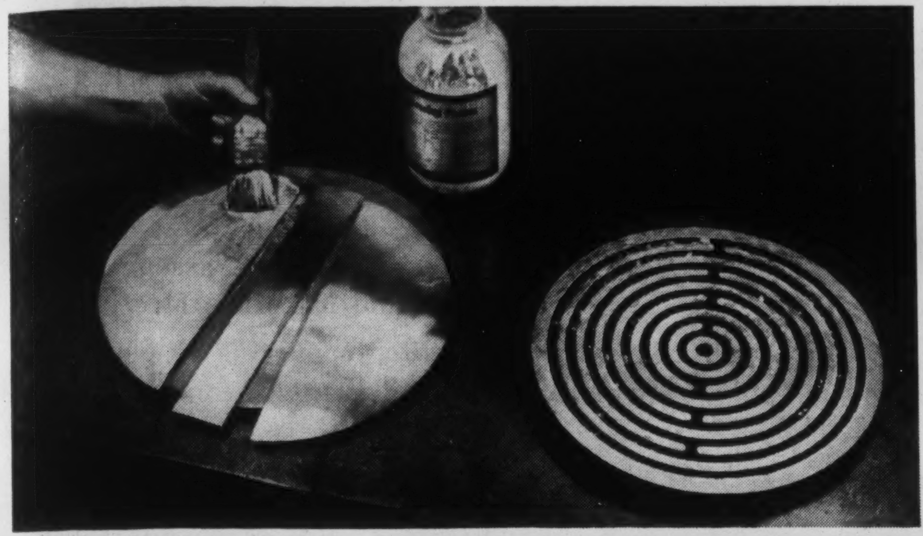
GE metallurgists say ". . . only by understanding the basic microstructure of metals on a fantastically small scale will it be possible to 'design' the super strong materials needed for forthcoming planes, rockets and missiles."

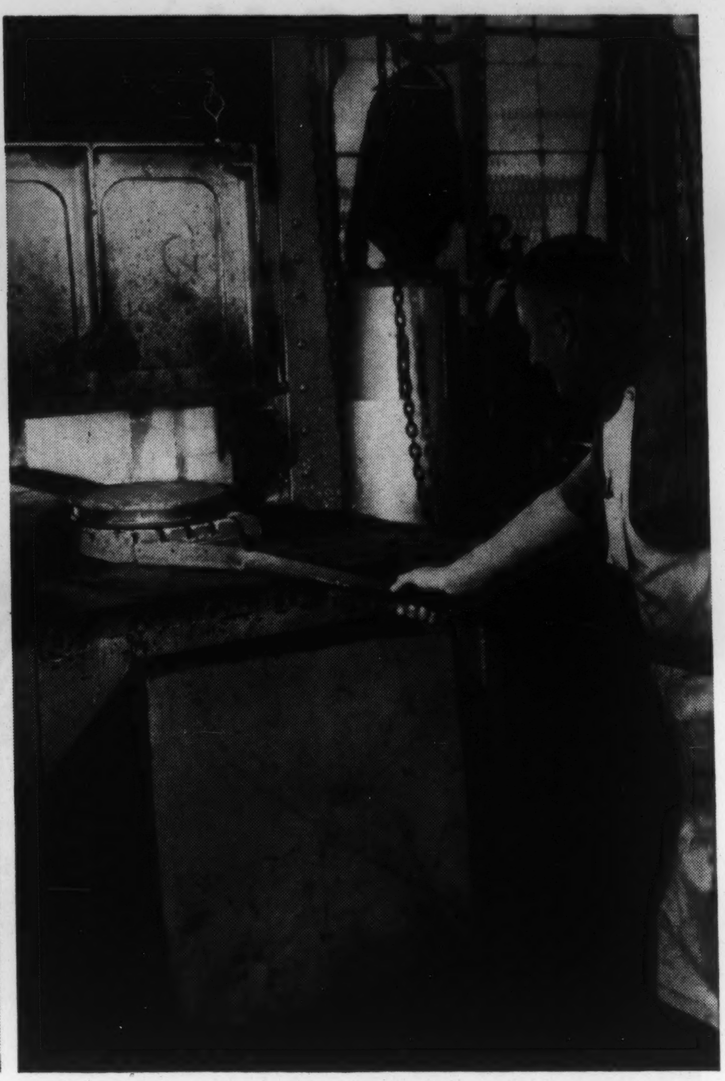
Two Car Finishes Have Durable Gloss

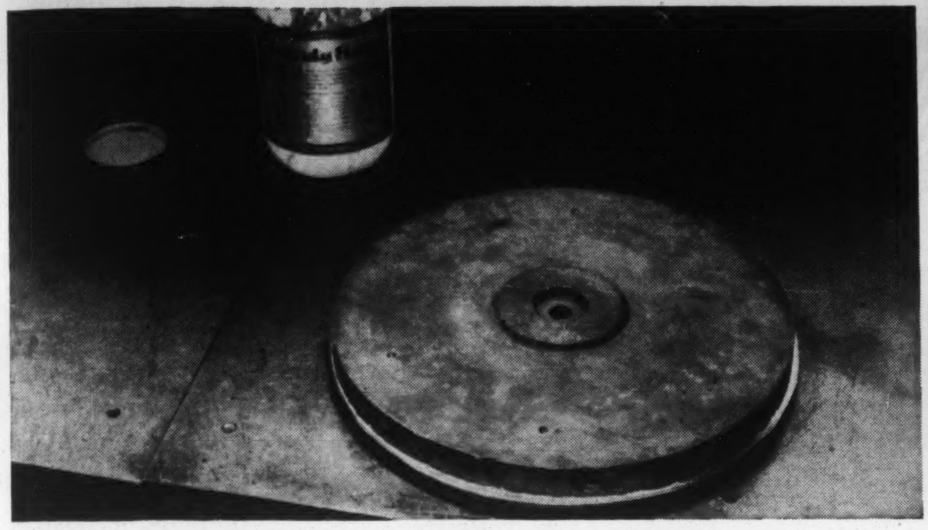
Hard, durable and weather resistant metallic and pastel colored automobile finishes are produced by two relatively new automobile paints. Both paints, an air drying lacquer and a baking enamel, are claimed to retain their gloss three times longer than conventional automobile paints (see MATERIALS & METHODS, Mar '56, p 160).

Last spring, J. D. Pickens and T. R. Matthews, both of E. I. du Pont de Nemours & Co., compared the properties of these new paints, Lucite lacquer and Dulux 100 enamel, with those of conventional nitrocellulose lacquers and synthetic baking enamels. They pre-

Insert halves are first carefully cleaned and fluxed. The sheet of EASY-FLO, .005" thick, in three sections, is liberally fluxed with HANDY FLUX. Following this, the halves are put together with EASY-FLO as a "sandwich filler" (below, left). Entire assembly is heated to a brazing temperature of 1170° F.







How EASY FLO Helps COLUMBIA RECORDS make records

EASY-FLO is put to excellent use in the die inserts (or backing plates) used in the manufacture of Columbia Records at the company's Bridgeport, Connecticut, plant. These die inserts are the heating and cooling elements used in the actual plastic record molding; in a very real sense, they are *behind* the entire record-making operation. The die insert assembly consists of two steel plates, the bottom plate being grooved to permit the passage of steam, at a temperature of 300° F under a pressure of 130 lb., followed by cold water at a pressure of 120 lb. When joined, they must be absolutely leak-tight and strong enough to stand up under thousands and thousands of stampings through drastic temperature changes and thermal shock.

These brazed backing plates have a life cycle of some 250,000 records; they are usually retired because of warpage in the steel, rarely for joint leakage.

This example illustrates just a few of the qualities that make silver brazing such a superior joining method. Strength under high pressure, resistance to temperature changes and thermal shock, and production ease; one, or all, of these qualities may apply to your product or production operation. We will be happy indeed to show you how you can benefit from this blue-ribbon method of joining all kinds, shapes and sizes of metals—similar and dissimilar. BULLETIN NO. 20 will get you off to a good start on the values, techniques and economies of low-temperature silver brazing. Write for your copy.

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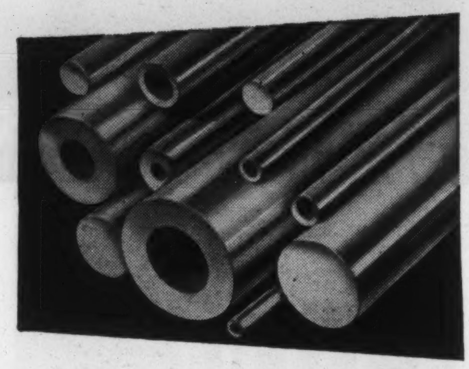

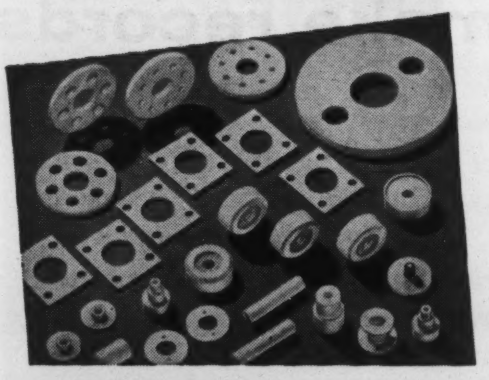

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sented their views at the 1957 SAE National Passenger Car, Body and Materials Meeting.

Acrylic lacquer

Lucite lacquer is an acrylic type paint and dries by solvent evaporation much like nitrocellulose lacquer. It can be readily spot repaired and in general handles like nitrocellulose lacquer in spraying and processing operations. According to the authors the outstanding property of Lucite lacquer is its excellent resistance to chalking and dulling in service. Tests conducted on painted panels exposed to hot sunlight show that the best nitrocellulose lacquers in most colors lose a considerable amount of their luster within six months. The same colors in Lucite lacquer lose little luster after 12 months exposure to continuous sunlight. According to Pickens and Matthews, the excellent weather resistance of the acrylic lacquer makes possible automobile paint colors which previously were not durable enough for production line use. This is true of the so-called "glamor colors" in which most of the pigment is aluminum flake.

The new paint, unlike conventional lacquers, is soluble in aromatic hydrocarbons such as benzene, xylene and toluene, but is not attacked by aliphatic hydrocarbons. It is resistant to high test gasolines, oil, grease and tar.

The authors point out that a special bond coat should be used if both nitrocellulose and acrylic lacquers are to be used on the same production line.

New enamel

Dulux 100 enamel is essentially a baking enamel and cannot be used as an air-drying product like most conventional enamels. The film forming ingredients in Dulux 100 are only partially formed when sold to the user. In order to provide optimum film properties these partially reacted film

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formers must be baked at a temperature of 250 F.

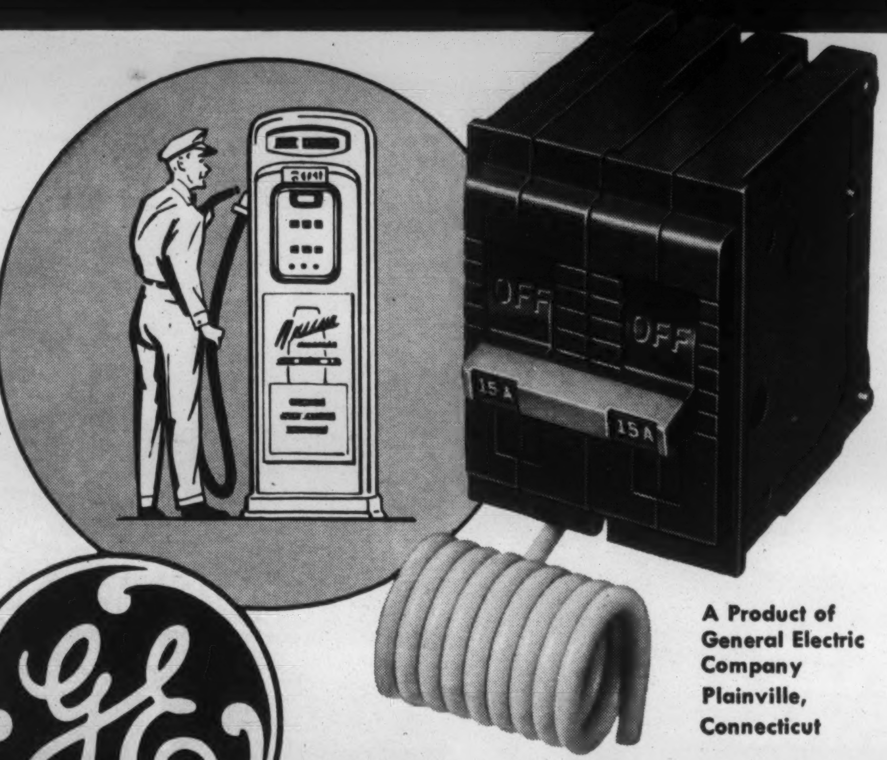
An outstanding feature of the new enamel is its good resistance to moisture blistering. As a rule, air-dry paints have better resistance to the formation of blisters than baked enamels. However, extensive tests conducted under extremely severe conditions, such as a hurricane where rainfall and high humidity prevail for a number of days, show that the new enamel has better blister resistance than most oven baked synthetic enamels.

Probably the most important advantage of the enamel, according to the authors, is its exceptional resistance to discoloration upon repeated baking. In order to produce the multicolored finishes now popular with the public it is necessary to process a car body through a baking oven two or three times. Conventional enamels in the light pastel shades show considerable discoloration when baked repeatedly, whereas Dulux 100 is not discolored even after several baking operations.

The enamel is claimed to be much harder immediately after baking than conventional enamels. This extra hardness is advantageous to the automobile manufacturer because the finish has less chance of becoming damaged on the production line; it also permits the manufacturer to polish out dirt without refinishing.

Automobiles finished with the new paint have been in service for over a year without any chalking, dulling, cracking or blistering of the finish taking place, according to Pickens and Matthews.

USE THE 'SELECTOR'—You will find properties of most engineering materials, plus names and addresses of suppliers, in M/DE's *Materials Selector* reference issue, published last September.



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TYPE TQL CIRCUIT BREAKERS

The "Fill 'er up!" order at gas stations is carried out with maximum protection against short circuits or overloads in the dispensing pump circuit, thanks to General Electric Company's widely-used Type TQL switching neutral, common-trip circuit breaker. This device is designed to disconnect ALL conductors of the circuit from the source of supply, thus meeting NEC (National Electrical Code) requirements.

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The Type TQL circuit breaker is one of the G-E series of molded case circuit breakers which employ thermostatic bimetal elements manufactured and assembled entirely by Chace. To insure maximum circuit protection and instantaneous trip-action all Chace bimetal elements are precision-rolled to the closest tolerances, specially processed to prevent metal separation, "torture-tested" under gruelling conditions, and rigidly inspected. This 4-phase leadership program—adhered to for over a third of a century of exclusive bimetal specialization—explains why more quality-conscious manufacturers look to *quality-famous* Chace in more bimetal applications than any other company in the field.

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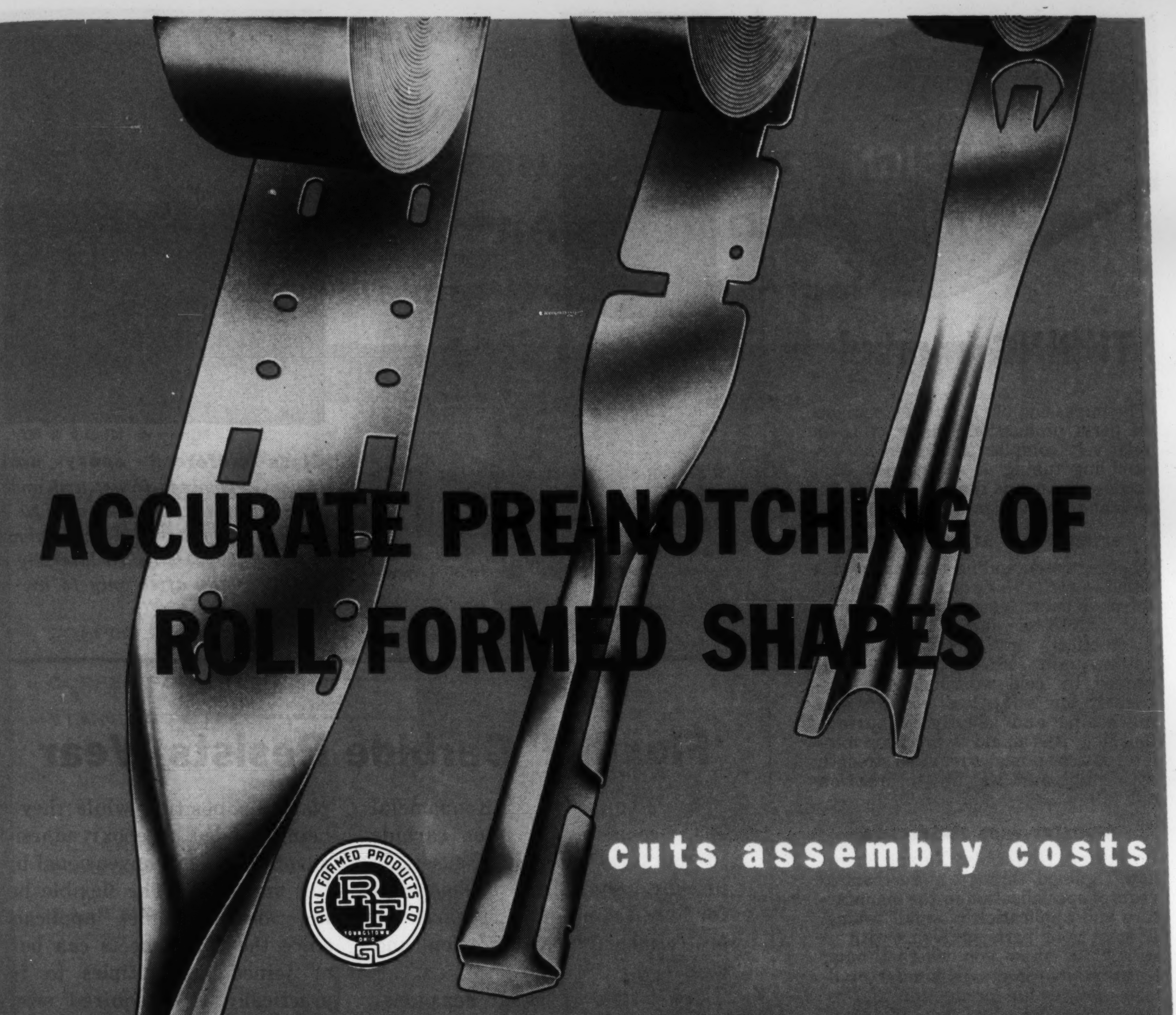

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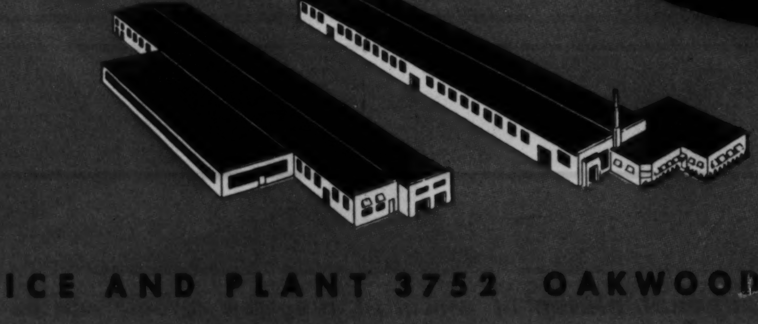

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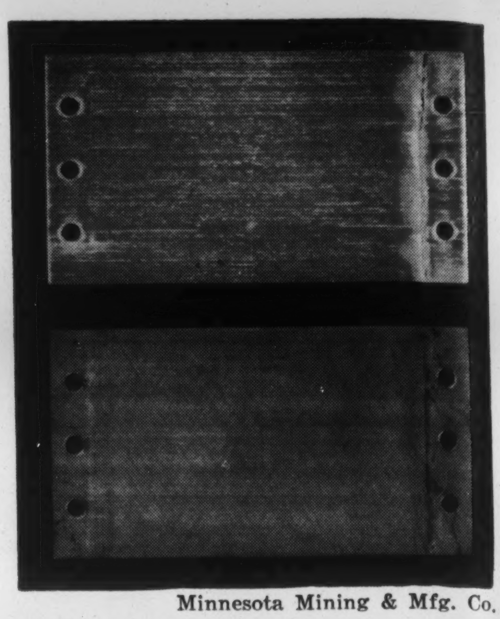
MATERIALS AT WORK

Epoxy springs—cont'd from p 12

directionally, isotropically or cross-plied) to meet individual requirements.

This article is based on an entry in last year's "Best Use of Materials" Awards Competition.



Minnesota Mining & Mfg. Co.

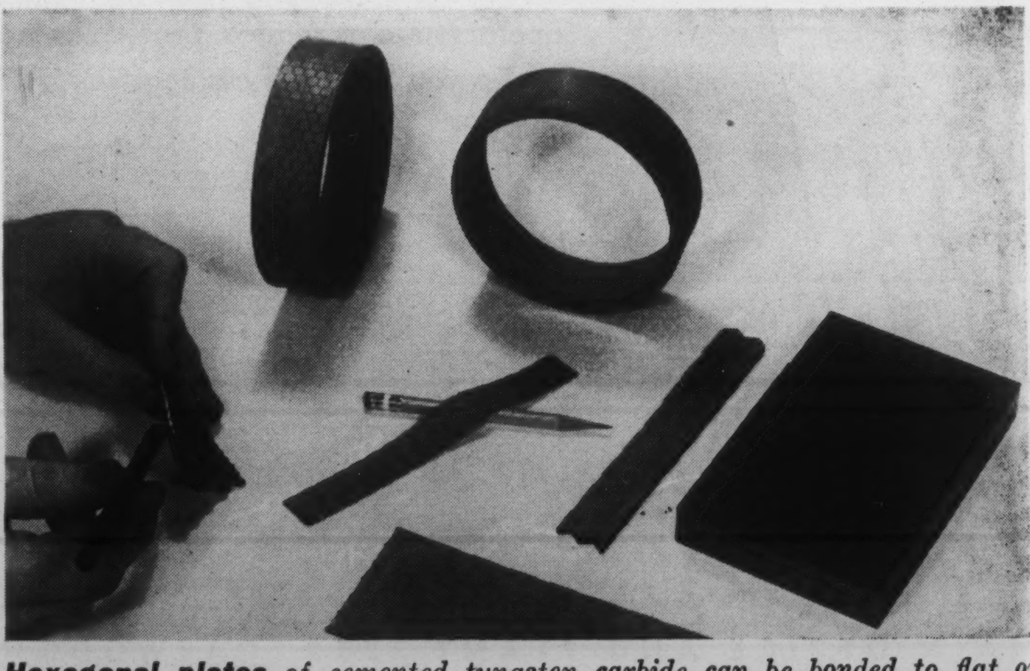
Glass-reinforced epoxy spring *(below) remained intact and undamaged after three weeks and 20 million cycles; glass-reinforced polyester spring (above) cracked laterally and longitudinally after only 15 hr.*

'Flexible' Carbide Resists Wear

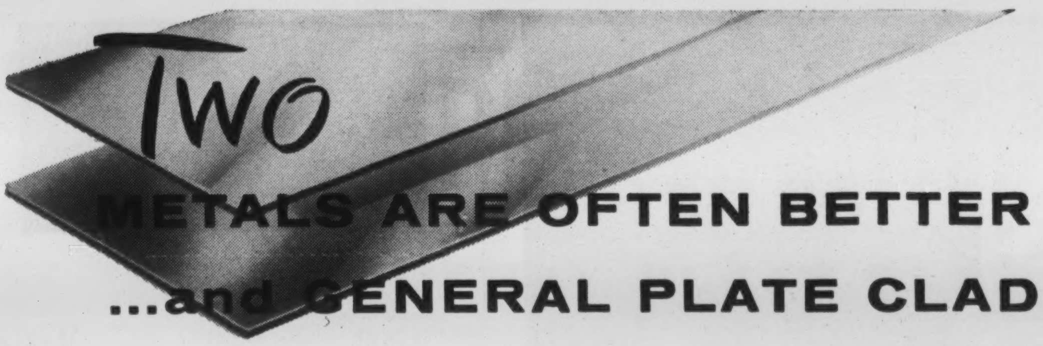
An adaptation of Kennametal Inc.'s cemented tungsten carbide in the form of flexible sheets is proving to be an effective material for hard facing metal surfaces for protection against abrasion and wear.

Consisting of small hexagonal plates of cemented tungsten carbide assembled in a continuous pattern on an adhesive glass fiber backing, the flexible sheets or strips can be applied on flat or curved surfaces. The adhesive backing is used to hold the small plates in position while they are being bonded by epoxy adhesives, silver solder or conventional brazing materials. The flexible backing also simplifies application, since the basic sheets can be cut or joined in multiples to form practically any required size or shape.

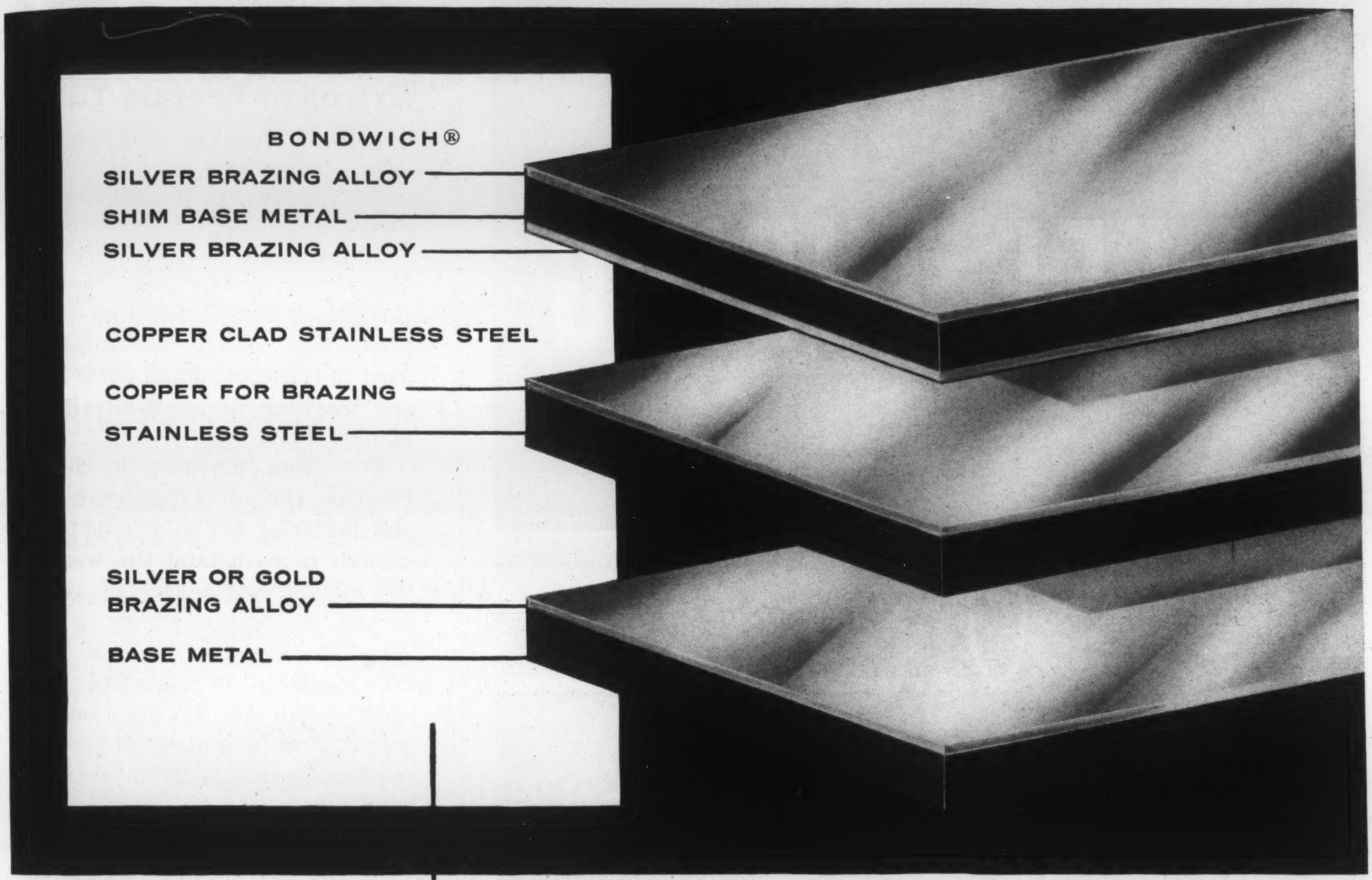
The hexagons are available in two sizes—0.425 and 0.210 in. across the flats—and in thicknesses of 0.040, 1/16, ⅛ and ¼ in. After application, normal joint spaces are said to be less than



Hexagonal plates *of cemented tungsten carbide can be bonded to flat or curved surfaces.*



Two METALS ARE OFTEN BETTER THAN ONE ...and GENERAL PLATE CLAD METALS for brazing are a case in point–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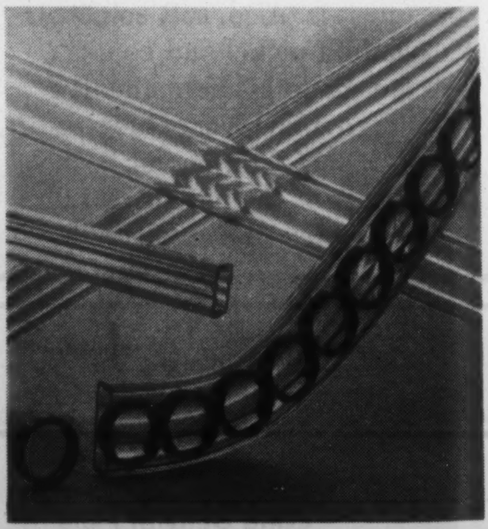
0.002 or 0.003 in. Maximum smoothness can be achieved by grinding the surface after application.

Extruded Acetate Tubes Convey Metal Parts

An unusual application of cellulose acetate tubes is shown in the accompanying photo where ball bearing races are seen traveling through a sample section. In a production set-up, the tubes are used to transport small parts from one machine to another without manual handling.

The tubes, extruded by Jessall Plastics, Inc. of transparent, durable material, are said to be tough enough to withstand the wear of the moving parts as well as the impact at points where a conveyor changes direction. The tubes are available in standard sizes ranging up to 2⅛ in. outside height and may be cut to any required length with an ordinary hand saw.

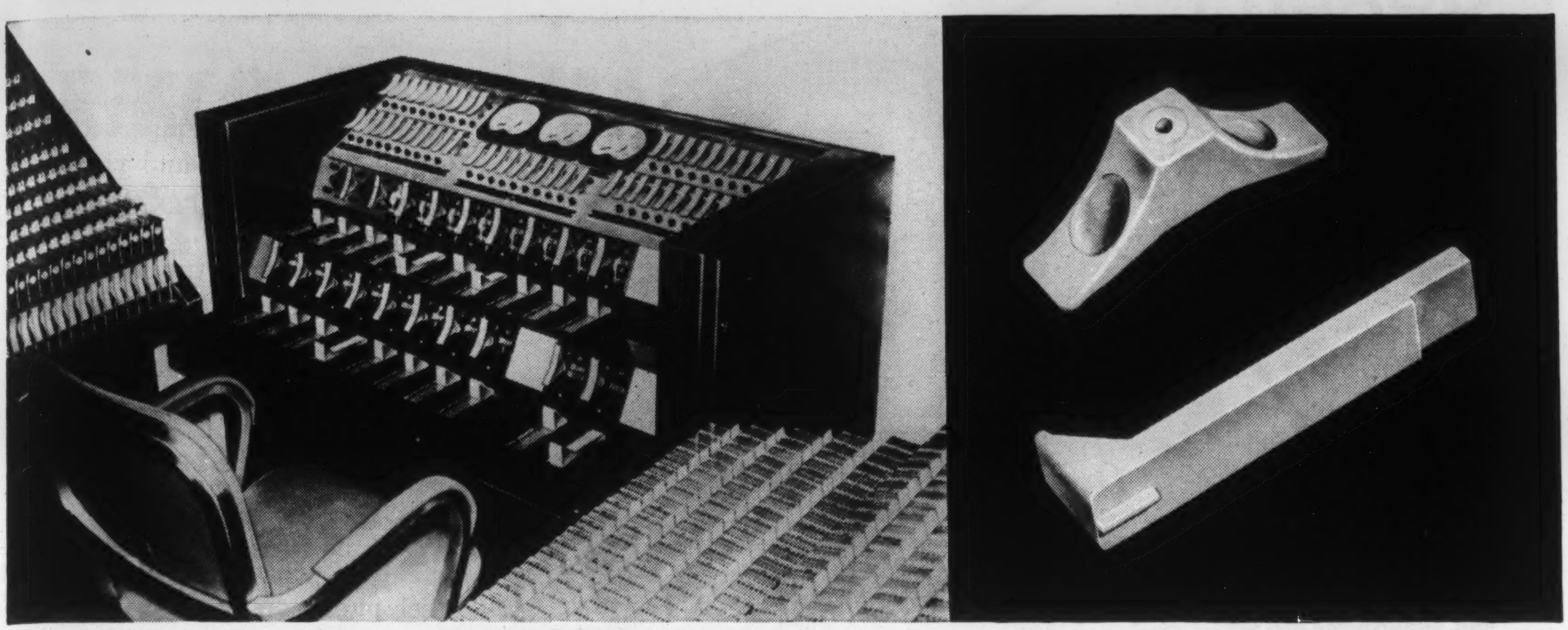
According to Eastman Chemical Products, Inc., supplier of the acetate, the sections of tubing may even be shaped or curved by simply packing with water soluble salt, heating briefly to 170-180 F and bending. The salt, which serves to sustain the original cross section, may be easily washed out



Transparent tubing *allows production flows to be easily observed.*

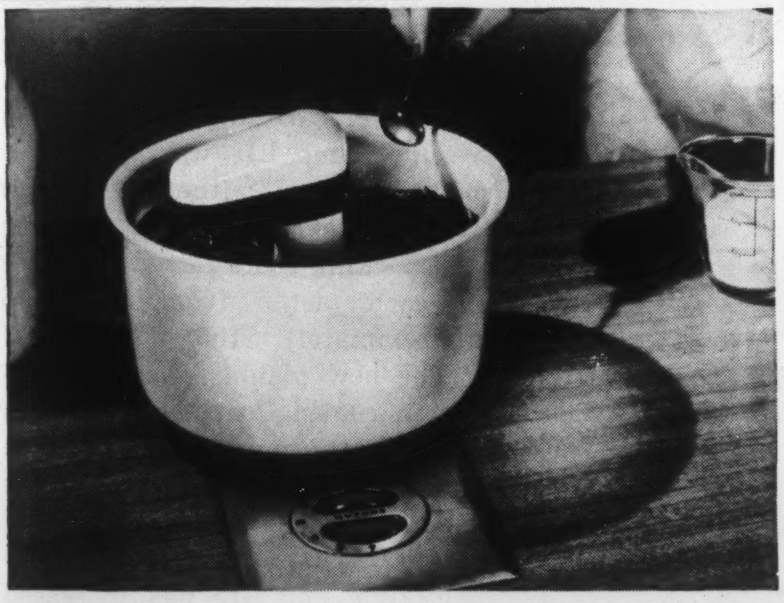
CYANAMID

PLASTICS NEWSFRONT



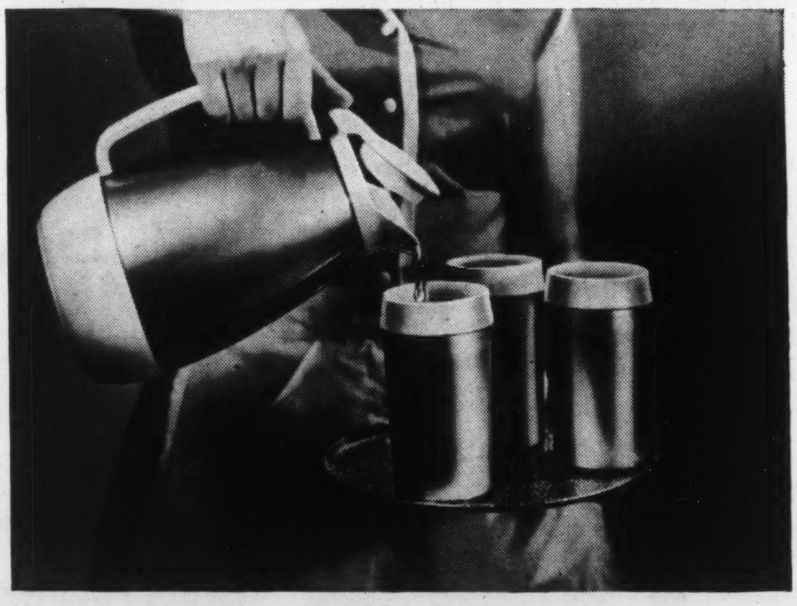
Plastic Keys Conduct an Orchestra of Light

One operator can play infinite variations in stage-lighting effects on the plastic "keys" of the Lumitron Lighting Control System. Control handles and slide bars are molded of BEETLE® urea plastic, an excellent dielectric which requires no insulation. Permanent, molded-in colors permit quick circuit identification. Developed by Metropolitan Electric Manufacturing Company, the Lumitron has an excellent record of performance.



"Five-in-One" Counter-Top Appliance Features CYMEL® Plastic Accessories

The new multipurpose NuTone Food Center operates a mixer, blender, meat grinder, knife sharpener and fruit juicer from one motor that can be set flush in a counter top Counter clutter, tangles of electric cords and heavy separate appliances are eliminated. A gleaming white 3½-quart bowl made of CYMEL melamine molding compound serves the mixer and juicer. CYMEL makes the bowl lightweight, dent-proof and easy to handle. The bowl is molded for NuTone, Inc., by Prolon Plastics Division of Prophylactic Brush Co.



New Insulated Beverage Set Joins Growing List of Boilable CYMAC® Housewares

Suitable equally for hot or cold beverages, these new double-shelled Thermo-Serve tumblers and pitchers are molded of CYMAC 201 methylstyrene, Cyanamid's new heat-resistant thermoplastic. This CYMAC ware resists staining by fruit acids, coffee and other beverages, and can be washed in boiling hot water, even in automatic dishwashers, without cracking or warping. All parts are injection-molded by NFC Engineering Company and sealed together under heat.

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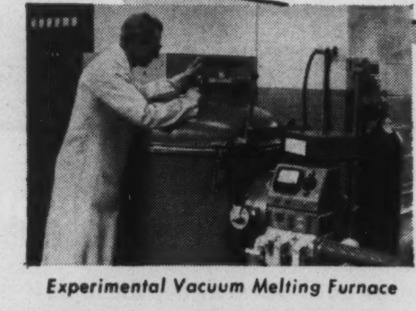

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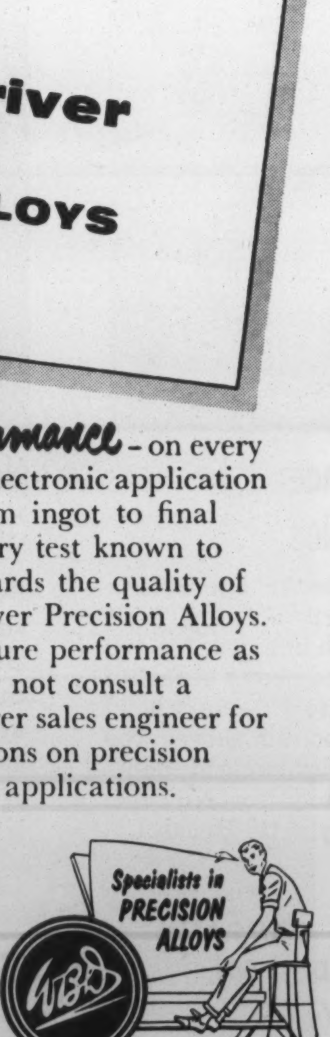

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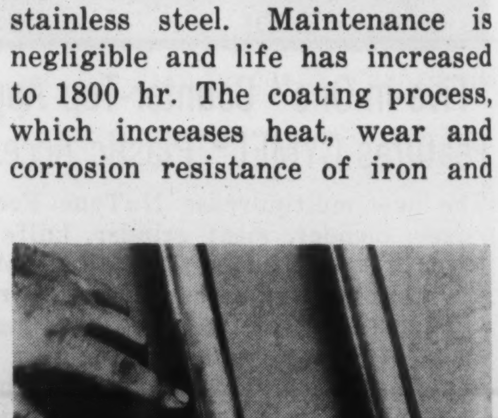
after the tube is shaped and cooled. At room temperature the tube becomes firm and rigid, and is said to hold its new shape permanently.

The conveyor tubing can be adapted to pneumatic, mechanical or gravity methods of conveyance.

Chromized Steel Replaces Stainless

The replacement of stainless steel pump pistons by chromized carbon steel has resulted in cost savings of over 50%. The stainless pistons, an integral part of water pumps used to clean sand castings in a gray iron foundry, were found to fail as a result of severe abrasion caused by sand particles—even though the pumps were fitted with dust shields and the water carefully filtered. As a result, pump life was limited to 600 hr. And although pistons could be reground twice, grinding and packing costs raised the price of each piston from $42.50 to approximately $105.

The new pistons, made by diffusion coating carbon steel with chromium, have proved three times more durable and 50% less expensive than those made of stainless steel. Maintenance is negligible and life has increased to 1800 hr. The coating process, which increases heat, wear and corrosion resistance of iron and



Stainless steel pump piston *(left) and chromized carbon steel piston (right) after 650 hr of service.*

Why production steps up with ARMCO FREE-MACHINING Stainless Steels

In service, the toughness of stainless steels gives them endurance that ordinary metals can't match. But in part-production, this very toughness can limit machining speeds. That's why Armco produces free-machining counterparts for many widely-used grades of stainless steel bar and wire. Small additions of certain elements make these special grades machine faster. Production rates jump.

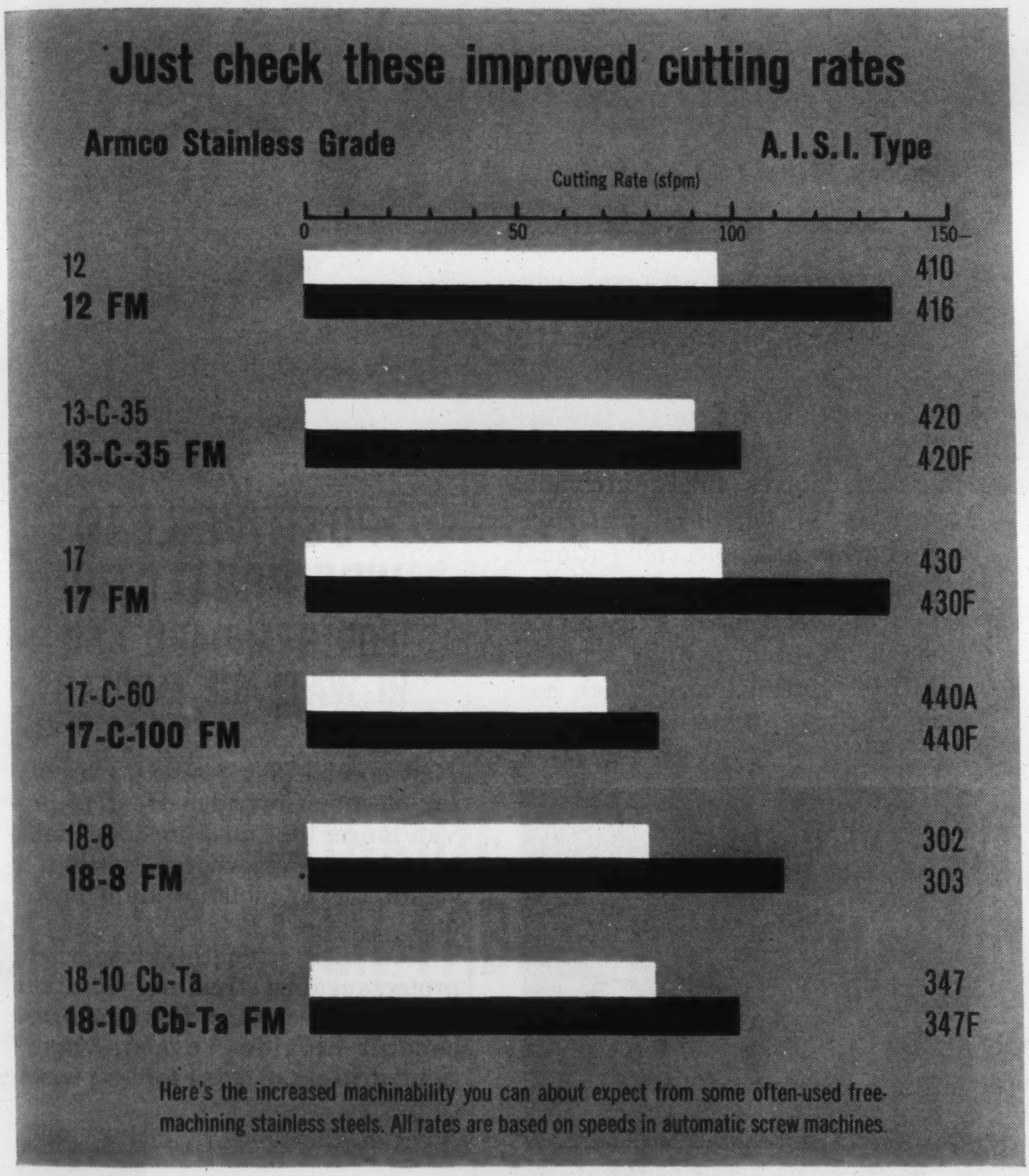
TRY THEM

Here's how to prove it for yourself. If you now machine parts from a standard stainless steel, just contact your nearest Armco Sales Office or Armco Stainless Distributor. They will be glad to arrange for you to try out the Armco Free-Machining counterpart of the grade you are now using.

Or, if you would like more information about uniform-quality Armco Stainless Steel bar and wire, just fill in and mail the coupon.

• • •

In addition to stainless steel sheet, strip, plate, bar and wire, Armco produces these other steels for top-quality products: ALUMINIZED STEEL, ZINCGRIP®, ZINCGRIP PAINTGRIP®, Cold-Rolled PAINTGRIP, Enameling Iron, Electrical Steels, High Strength Steels, Welded Steel Tubing, and Long Ternes, as well as high-quality hot- and cold-rolled sheets.



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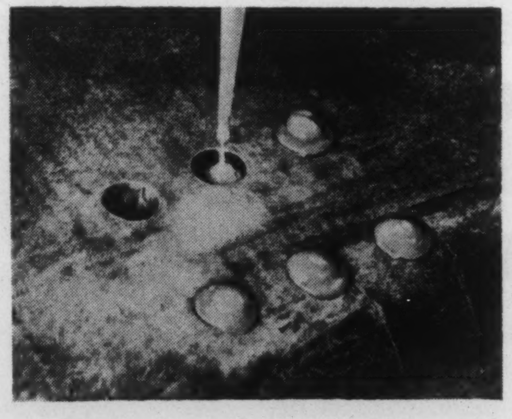
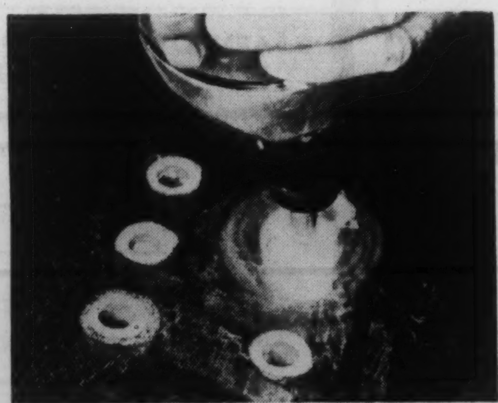
steel parts, involves a high temperature exchange of iron and chromium atoms at the surface of the part, providing it with a chromium carbide outer layer that is integral with the base metal. Chromizing is performed by Chromalloy Corp. of Yonkers, N. Y.

Epoxy Resin Putty for Sandwich Fastening

Lightweight sandwich constructions are becoming increasingly essential in the fabrication of aircraft and missile components. However, the problem of developing suitable methods of attaching these structures to an airframe continues to puzzle aircraft designers. For example, conventional mechanical fasteners are seldom practical for attaching sandwich components because they tend to crush the internal core which has comparatively little compressive



1. ***Resin is inserted*** *in holes with sealing gun to form plug.*



2. ***Holes are drilled*** *in each plug.*

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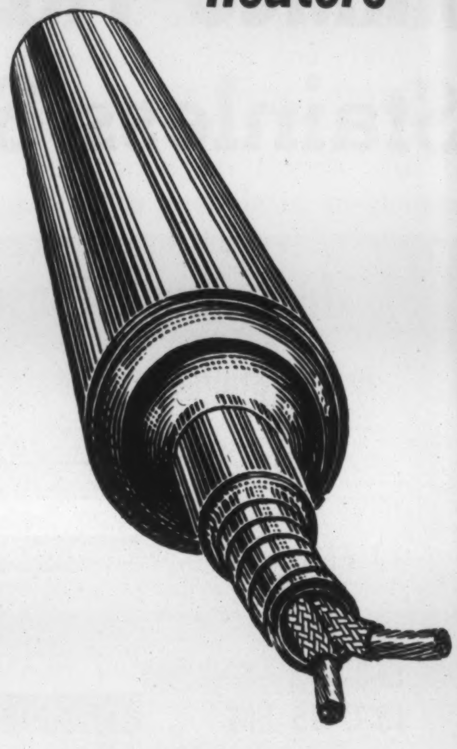
electric cartridge heaters



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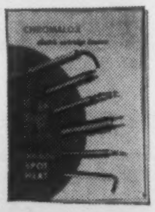

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Q. A zinc-coated steel that won't peel or flake? That could save us a lot of money every month. Just what makes this Weirkote so special?

A. It's made by the continuous process, you know, which integrates zinc and steel so that the toughest fabrication won't break down the bond. You can work Weirkote to the very limits of the steel itself.

Q. Of course, that means the most complicated parts would have protection against rust. I like what I'm hearing. Is there more?

A. Yes . . . now Weirkote is treated to inhibit wet storage stain (white oxide). To make a long story short, I'd say this: With Weirkote, you can turn out a better product at lower cost. And you can free a lot of the capital, floor space and time you have tied up in plating operations.

Send for free booklet that details the time- and cost-saving advantages of skin-tight zinc-coated Weirkote. Weirton Steel Company, Dept. E-7, Weirton, West Virginia.

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WEIRTON STEEL COMPANY
WEIRTON, WEST VIRGINIA
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What.... do YOU know about GRAY IRON CASTINGS?

30 SECOND QUIZ

1. Given a properly cleaned gray iron casting, does aging it outdoors several months improve machinability or not?
☐ Quite a bit ☐ A little ☐ Makes no difference

2. Gray irons are available under standard specifications with tensile strengths from 20,000 psi to ______ psi.

3. Ductile iron castings may be purchased under standard specifications with strengths as high as ______ psi.

4. What is the maximum temperature at which a high strength gray iron casting can maintain its load carrying ability?
______

5. To get the needed strength, finished automotive crankshaft castings would have to be approximately how much heavier than finished forgings?
☐ 50% heavier ☐ 20% heavier
☐ 10% heavier ☐ no heavier

NOW turn upside down for answers

1. Makes no difference.
2. Standard "specs" go up to 60,000 psi.
3. A 120,000 psi is available with heat treatment.
4. Non-pressure applications up to 800° are used.
5. Cast crankshafts may actually be lighter than forged.

NEW 620 PAGE HANDBOOK. Save money. Use the new Gray Iron Castings Handbook with complete cost-cutting, design and purchasing information on new ductile, regular and special iron castings. Over 400 illustrations. 64 tables. Mail coupon for TEN DAYS FREE EXAMINATION. At the end of the examination period remit $10 or return the book.

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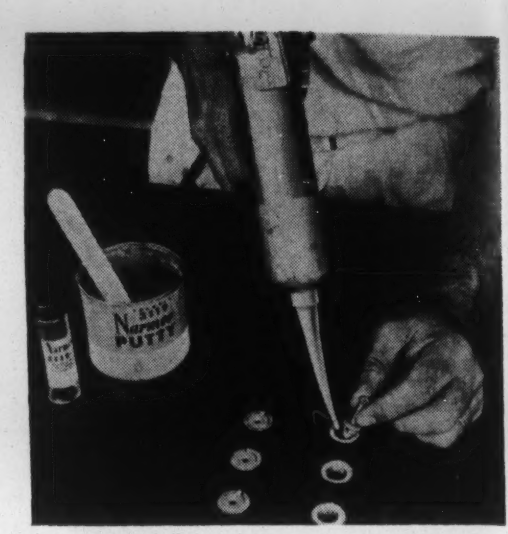
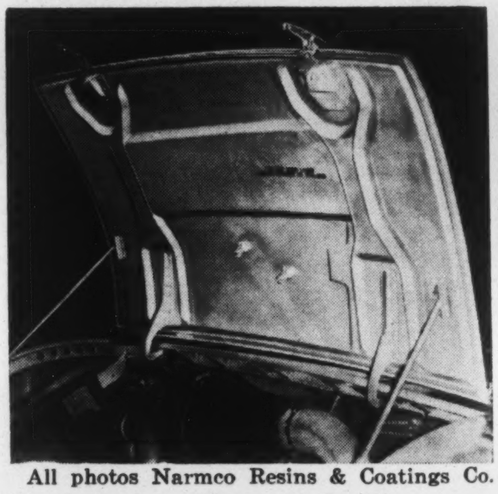


3. Fasteners are inserted *and sealed into each plug.*



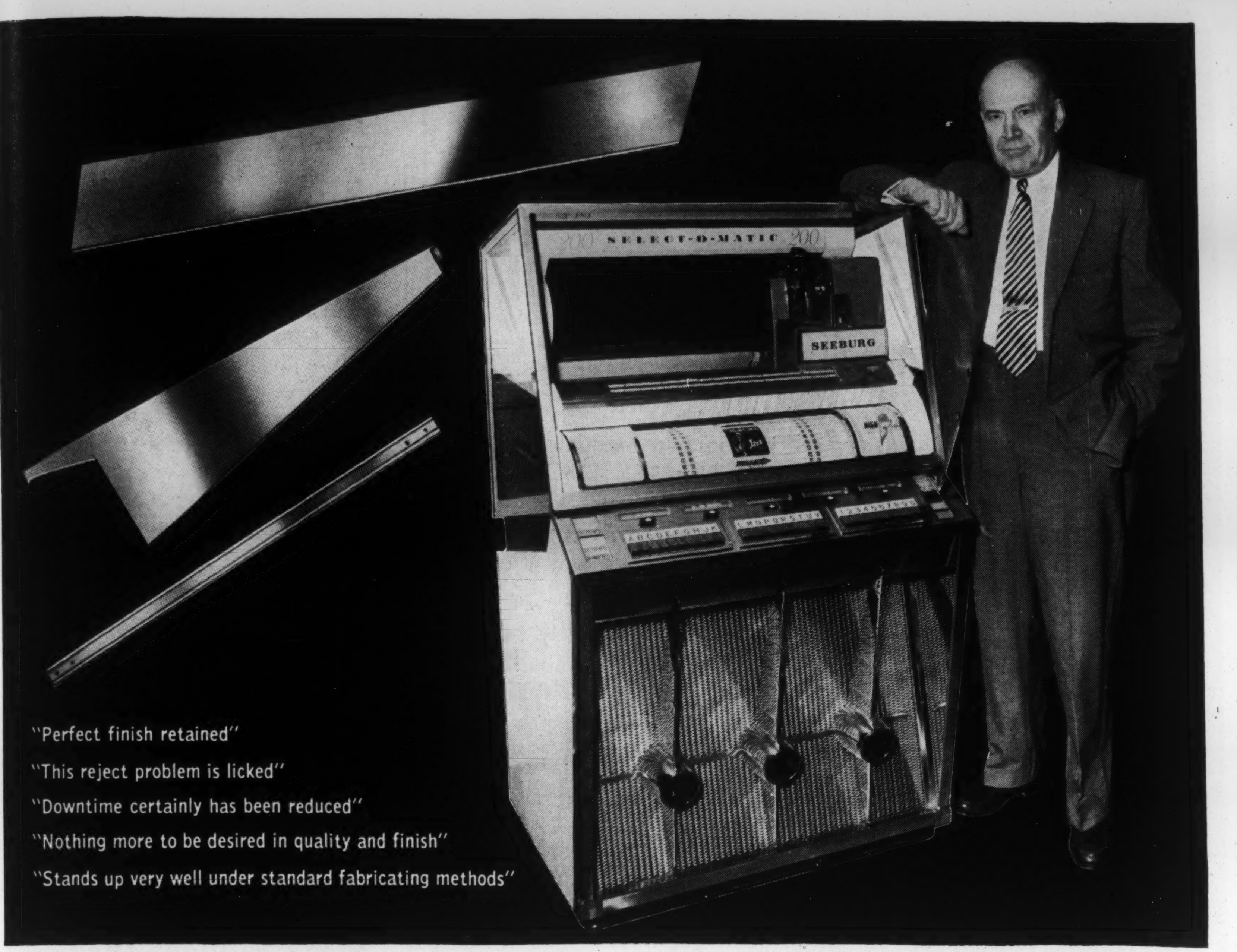
All photos Narmco Resins & Coatings Co.

4. Interior view *of landing gear pod access doors showing hinges, latches and locking mechanism.*

strength in highly localized areas.

One successful solution to the sandwich attachment problem has been worked out by Douglas Aircraft Co. In the C-133A turboprop cargo transport, eight access doors located on the twin landing gear pods are fabricated of multiple layers of honeycomb aluminum core faced with fiberglass skins. To attach metal hinges and the locking mechanism to each of the lightweight doors required 40 through-sandwich attachments and 20 blind attachments. Douglas engineers were able to do the job by using a room-temperature-curing putty made of epoxy-type resin.

To attach the hinges, 20 ½-in. holes were drilled through one skin and the core. The surround-



"Perfect finish retained"

"This reject problem is licked"

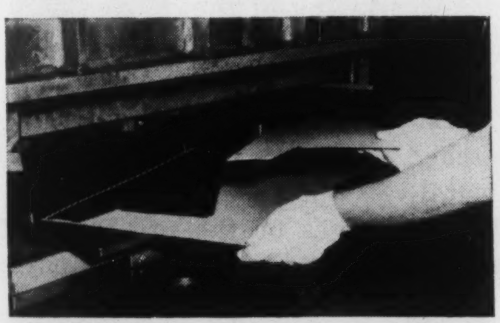
"Downtime certainly has been reduced"

"Nothing more to be desired in quality and finish"

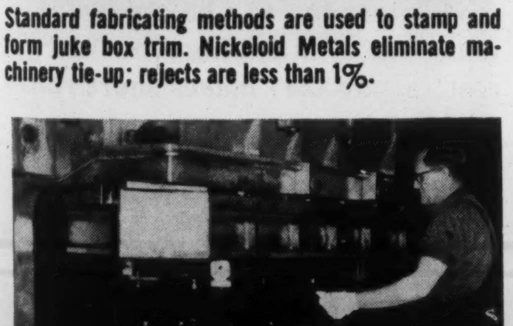
"Stands up very well under standard fabricating methods"

K. R. Craft, Vice President, The Seeburg Corp., Chicago, with one of the company's famous juke boxes. The brilliant reflectivity and durability of Nickeloid pre-plated metals is an important factor in the product's eye-catching good looks.

NICKELOID METALS SAVE 4 PRODUCTION STEPS—REDUCE REJECTS FOR THE SEEBURG CORPORATION



Standard fabricating methods are used to stamp and form juke box trim. Nickeloid Metals eliminate machinery tie-up; rejects are less than 1%.



Stamping Nickeloid chrome steel, protected with Mar-Not adhesive-backed paper which is easily peeled off. Finished part will need no polishing.

Pre-Finished Design Material is Easily Worked With Standard Fabricating Methods

The Seeburg Corporation uses Nickeloid *pre-plated* chrome steel to achieve functional beauty and attention-value . . . economically. Before switching to Nickeloid, the company did its own cleaning, plating and buffing. The job required four — sometimes five more operations than are now necessary. According to Mr. Craft, "The tremendous cost of plating and buffing was not only more expensive and much more time consuming, but the finished product had to be inspected, and the rejections on plated and buffed metals was very much higher than it is with Nickeloid. Economically, the Nickeloid Metals have proved themselves in production."

Using standard fabricating methods, Nickeloid Metals need only be stamped and formed — then assembled. By capitalizing on this pre finished *method* of production, this leading manufacturer has eliminated the machinery formerly required for plating, polishing and buffing — saved four or five production steps, and is producing a better end product *with less manpower*. Can you use these advantages in *your* operation?

14 finish-to-base metal combinations — sheets, coils, strips.

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ing core was then filled with putty to the first vertical cell column. When the putty had cured, ¼-in. holes were drilled through the putty plugs, and metal bolts were inserted and fastened with nuts to secure the hinges.

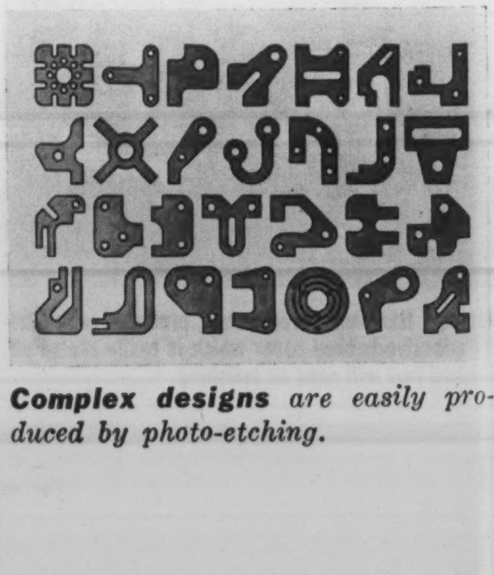
Blind attachments for the locking mechanism were made by forming similar putty core plugs within the core and fitting steel bolts through the internal skin into aluminum fasteners in the putty plugs.

According to Douglas, the putty-secured attachments have proved highly successful. In fact, shear tests showed that both the skins and the honeycomb core failed in considerably less time than did the attachments.

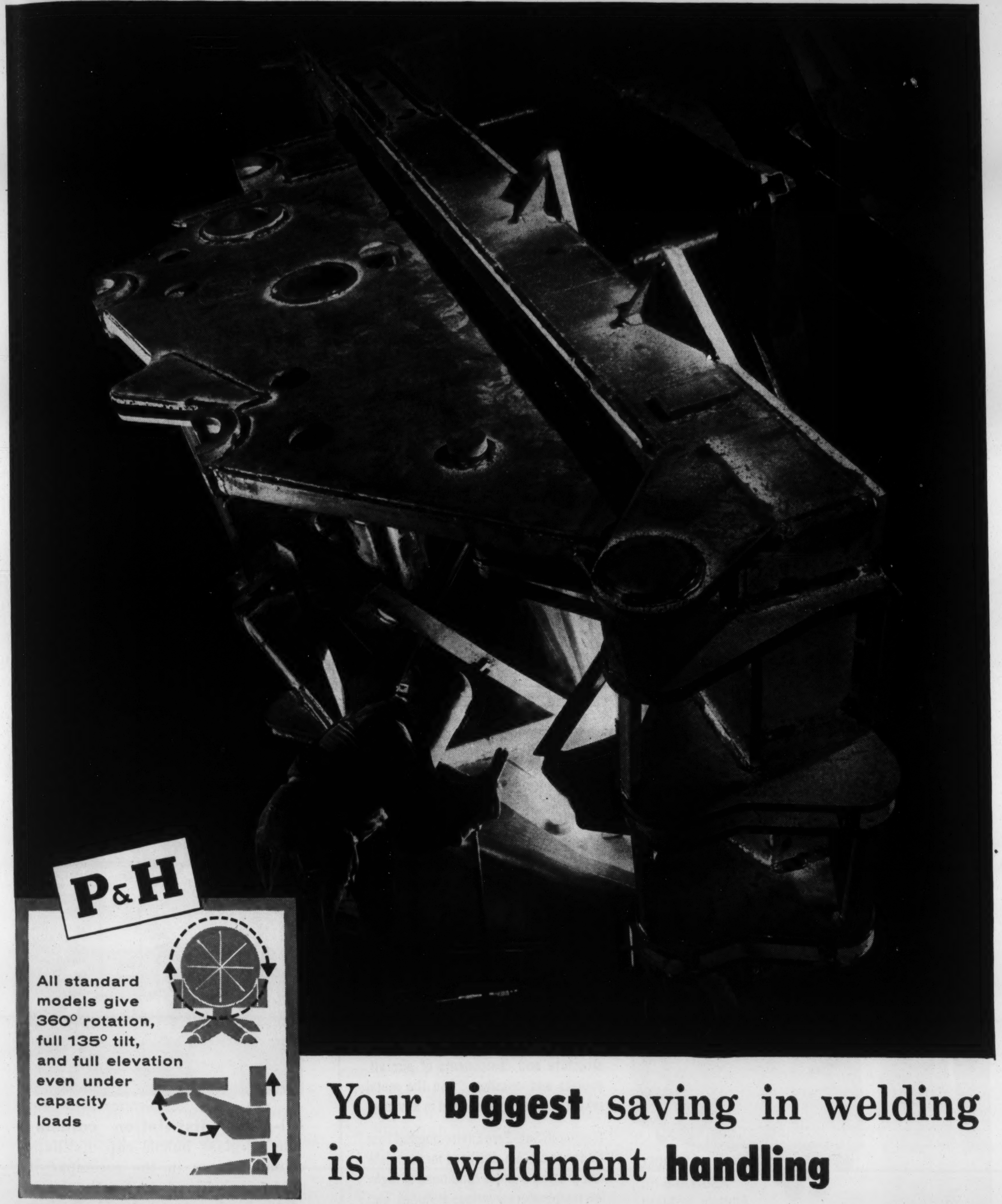
Intricate Metal Parts Made Without Dies

Thin metal parts with extremely close tolerances are easily produced without dies or presses by a process known as photo-etching. In the process, a large inked drawing of the desired part is photographed onto sheets of sensitized metal up to 0.016 in. thick. The parts are then acid-etched free from the surrounding metal.

Advantages of the process, according to Randolph Co. of Houston, Tex., are: it produces shapes too intricate to be made by punching or stamping; low initial cost (about $25) makes short runs



***Complex designs** are easily produced by photo-etching.*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RESULT: Increased production, less operator fatigue, metal flows more readily, pools more evenly to produce cleaner, stronger welds — because all welding is done in the natural *downhand* position.

For more information about how these useful machines can save you money, write to Department 310Q, Harnischfeger Corp., Milwaukee 46, Wis.

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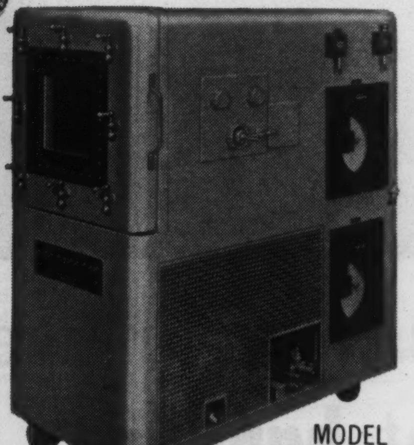

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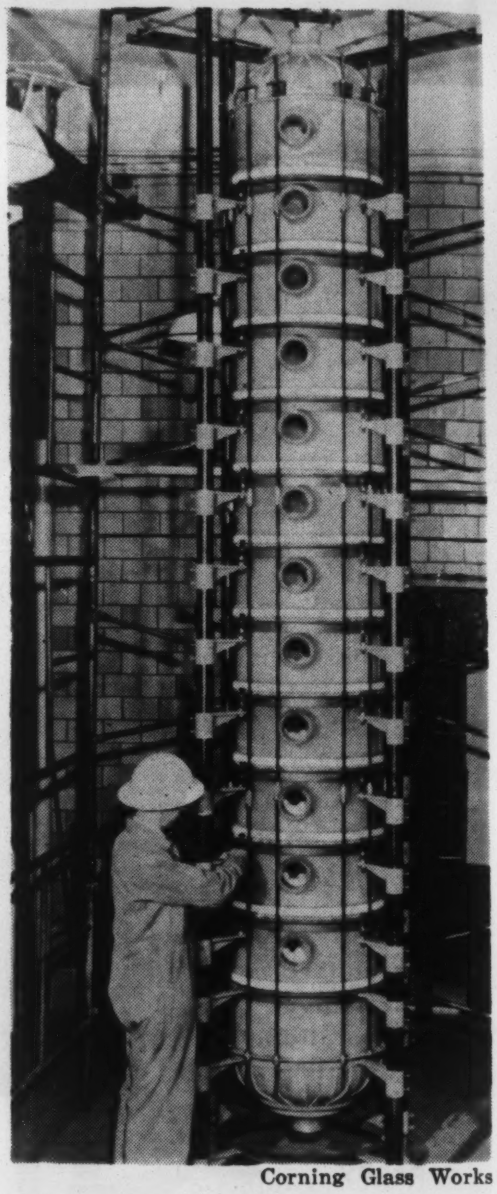
feasible; tolerances of 0.002 in. can be maintained; no burr is produced; and modification in design can be made in a few hours by simply reworking the original drawing and re-photographing.



Corning Glass Works

All-glass distillation column—The all-glass bubble cap distillation column shown in the accompanying photo is believed to be the largest of its kind ever produced. Designed for use in the manufacture of metallic silicon, the column stands 16 ft high, is 23½ in. in dia and weighs about 2000 lb. It is composed of 13 armored Pyrex cylindrical sections, each of which is sealed with Teflon envelope-type gaskets. Between the sections are 12 plates made of 96% pure silica glass.

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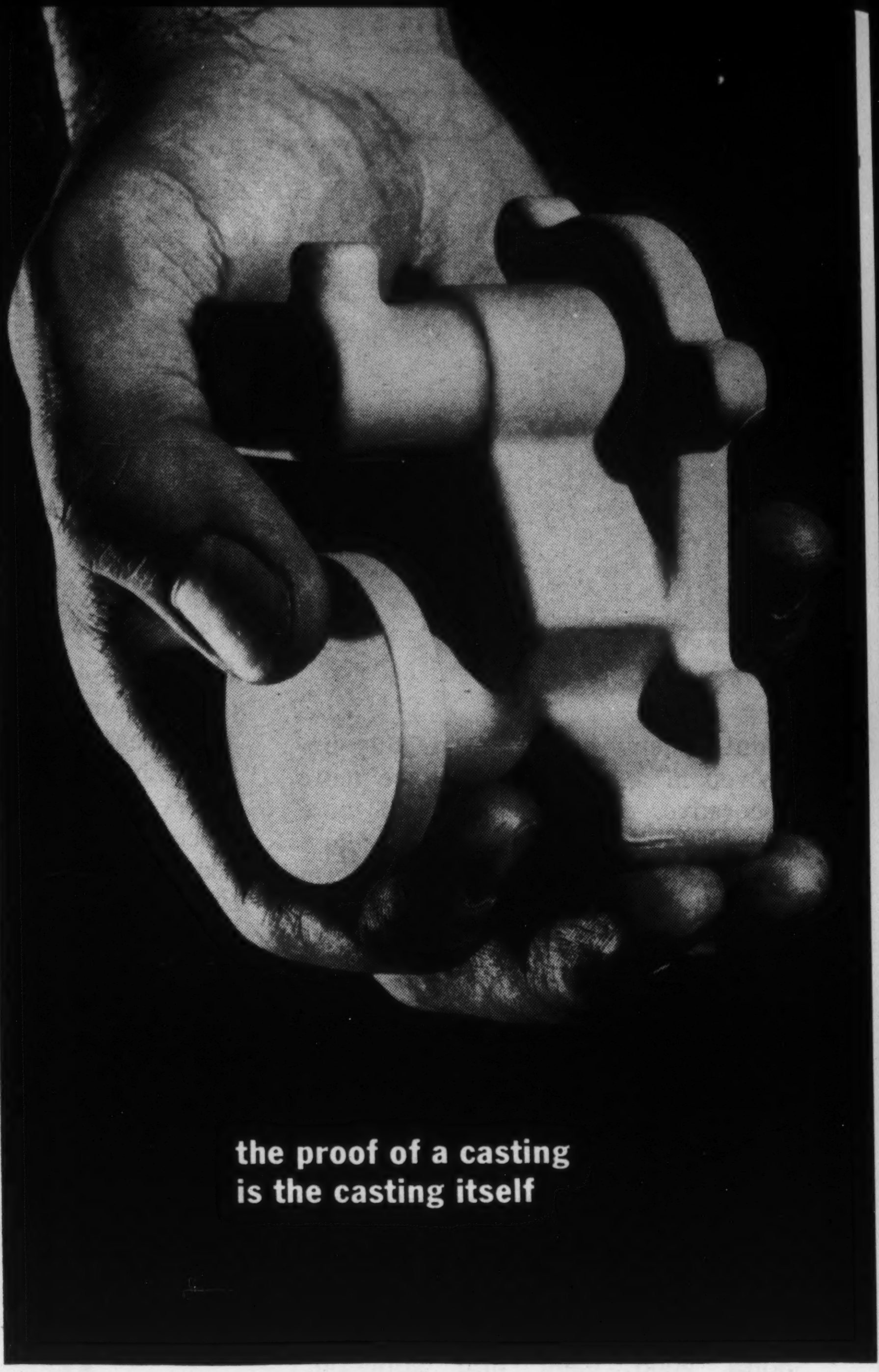
the proof of a metal
is a cast test bar



the proof of a casting
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It's easy to understand how this new process can help designers shuck off the historical limitations of aluminum investment castings. Now investment castings can be made smaller because they're stronger. Now they can be made lighter. Designers can work in *thick* sections because the new process is especially effective in these areas. And parts can be designed for structural applications because, for the first time, here is a high-strength aluminum investment casting with a measure of ductility.

And here is a practical consideration: If you are now using 356-T6 alloy castings, you can switch over to castings made by Arwood's new "Suparcast" process *without the need to change specifications.*

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Chemical Prepaint Treatments for Metal Surfaces

What they do, the types available, how they are applied

By J. H. GEYER
Manager, Product
Development Dept.,
AMERICAN CHEMICAL
PAINT COMPANY

Paint systems have been steadily improved in an effort to produce more decorative, easier-to-apply, and more corrosion-resistant films. The ability, however, of any paint film to perform its predetermined functions cannot be fully utilized without properly preparing the metal surface.

The prepaint preparation of the metal surface is therefore a highly important part of the system. Chemical prepaint treatments are designed to do four jobs and do them well. First, they remove organic soils, shop dirt, scale, and rust or corrosion products from the metal surface. Second, they provide surfaces that are completely compatible with subsequent paint films. Third, they produce a *tooth* that promotes good paint film adhesion. Fourth, they effectively prevent underpaint corrosion growth after any breakthrough in the paint film.

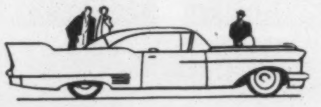
Basically, there are four types of chemical prepaint treatments. These are phosphoric acid, iron phosphate, zinc phosphate, and amorphous phosphate or chromate. Each is discussed briefly in the following paragraphs.

Phosphoric Acid

Perhaps the most widely used and certainly one of the most economical chemical prepaint treatments is the phosphoric acid cleaner combination materials. ACP Deoxidine® is such a material. It removes organic soils, rust, scale and contaminating elements from the metal surface. It also produces a light etch on steel, aluminum or zinc surfaces which considerably aids in increasing paint adhesion. It does not, however, form an actual coating on the metal surface. Any breakthrough in the subsequent paint film will permit underfilm corrosion to proceed. Grades of Deoxidine are available for application by brush or swab, hot and cold dip, or hot spray.

Iron Phosphate

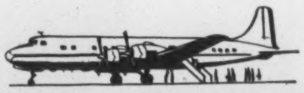
Iron phosphating processes are extensively used in the chemical prepaint treatment of appliances such as water heater shells, ranges, washers, dryers and other *white lines.* These processes will produce excellent paint-bonding films on the metal and retard or prevent underpaint corrosion. Duridine,® ACP's iron phosphating process, is a combination organic soil cleaner and iron phosphate coating material. Both the cleaning and coating operations take place in the same bath. Duridine and other iron phosphates do not lend themselves to brush-on application, are primarily designed for spray type equipment of four or five stages. But several dip installations are successfully operating today by inclusion of an alkali precleaning stage.



Zinc Phosphate

ACP Granodine® is an example of this type of chemical prepaint treatment process, the type now being used to treat steel in the automotive industry, and predominantly specified for steel ordnance and military items. This process forms a coating which offers the ultimate in paint adhesion promotion and vastly augments the corrosion resistance of subsequent paint films. Zinc phosphate materials are extremely flexible as to method of application—can be applied by brush, dip or automatic spray equipment. In a typical dip or power spray system, the stages would be alkali clean, water rinse, zinc phosphate treatment, water rinse, and acidulated final rinse. If the metal has considerable areas of rust or scale, an acid pickle is advisable following the alkali cleaning stage.

On zinc surfaces, the zinc phosphates perform a rather unique function. They act as a barrier against chemical reaction between the applied paint film and the zinc surface. This effectively prevents blistering of the paint and early breakdown of the film. This is in addition, of course, to the improvement of paint adhesion and the retarding of underpaint corrosion. ACP Lithoform® is specially designed for use over zinc surfaces and finds wide application as a prepaint treatment for ornamental zinc die castings, refrigerator liners, and on most galvanized work requiring painted finishes.



Amorphous Phosphate and Chromate

These coatings are the films produced by the ACP Alodine processes and similar ones on aluminum surfaces. They have met with wide acceptance in the prepaint treatment of venetian blind strips, refrigerator liners, aluminum heat transfer units, aircraft sheet metal assemblies, and many other items fabricated from aluminum. The various coatings provide an excellent film for the promotion of paint adhesion and effectively prevent underfilm corrosion. As in the case of zinc, aluminum exhibits a tendency to chemically react with some paint systems. The Alodine processes develop a barrier film between the paint and the aluminum surfaces which prevents this reaction. The Alodines are extremely versatile materials that can be applied to aluminum surfaces by brush, hand spray, dipping, mechanical spraying, or roller coating equipment. Brush application is particularly well adapted to the processing of parts too large for simple dip systems or in manufacturing operations that do not warrant a tank setup. In dip, spray or roller coating application, the system usually consists of an alkaline preclean, a water rinse, the Alodine treatment, a water rinse, and an acidulated final rinse. Where the surface is heavily oxidized, a deoxidizer in the line is needed.

The major chemical prepaint treatments for metals have been covered briefly in this article. More complete information can be had by contacting an ACP sales representative or by writing us at Ambler, Pa.

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PRICES AND SUPPLY

...AT A GLANCE

STEEL PRODUCTION DURING THE FIRST 11 MONTHS OF 1957 reached the second highest total on record. According to the American Iron and Steel Institute, the highest 11-month total was made in 1955 when the industry produced 106.5 million tons; in the similar period of 1957, the industry produced 105.3 million tons. Production during December, however, was only about 8 million tons.

PRODUCTION OF STEEL WILL CONTINUE HIGH IN 1958, predicts Max D. Howell, executive vice president, AISI. According to Mr. Howell, we can expect a total of 110 million net tons of ingots and steel for castings, as compared to 113 million tons in 1957. Steel-making capacity is expected to increase from 133 million to 140 million tons.

. . . AND STEEL PRICES MAY INCREASE. According to Joseph L. Block, president of Inland Steel Co., "Current steel prices are inadequate. They do not," he says, "permit a proper return on the investments in new facilities which the industry must continually make for modernization and expansion." These comments came in answer to a suggestion by a prominent Senator that a $3 per lb decrease would benefit the economy.

INCREASED AVAILABILITY OF SYNTHETIC RUBBER is slated for 1958 as a result of two new Du Pont expansions. Specific materials affected are neoprene and Hypalon (chlorosulfonated polyethylene). A 50,000,000-lb-per-year neoprene plant is now on stream near Montague, Mich., and a 15,000,000-lb-per-year Hypalon plant is operating in Beaumont, Tex.

SELENIUM PRICES HAVE BEEN CUT by American Smelting & Refining Co. Common grade is now $7.50 per lb, down from $10.50; high purity grade is now $10.50 per lb, down from $13.50; and ferroselenium is $8.00 per lb of contained selenium, down from $11.20. No reasons were given for the reductions.

OUTPUT OF VINYL ACETATE MONOMER WILL BE INCREASED by about 15 million pounds per year as a result of Air Reduction Chemical Co.'s latest expansion. The increase will raise the company's capacity to 45 million pounds. Vinyl acetate monomer is the basic constituent in resins used for water-based paints, adhesives, textile treating compounds and paper glazing and coating.

MORE TUNGSTEN IS AVAILABLE THAN IS BEING USED in spite of the fact that consumption in the first half of 1957 was about equal to U.S. production in that period. According to the Bureau of Mines, substantial imports during that period led to the abundance.

TWO MORE INCREASES IN POLYETHYLENE PRODUCTION have been announced recently: W.R.Grace & Co.'s Polymer Chemical Div. has begun production at its new 50,000,000-lb-per-year high density polyethylene plant in Baton Rouge, La.; and Eastman Chemical Products, Inc. has increased its Longview,Tex. plant's polyethylene capacity by more than 50% to 85,000,000-lb-per-year. A part of Eastman's new production will be devoted to medium density types.

GADOLINIUM, DYSPROSIUM, ERBIUM AND YTRIUM, four previously scarce rare earth metals, are now said to be available in commercial quantities from Rare Earth and Thorium Div., Michigan Chemical Corp. The materials are expected to find use as shielding and control rods in nuclear reactors.

COMMERCIAL GRADE ZIRCONIUM SPONGE is now available in tonnage quantities from Columbia-National Corp. The material, which contains about 2% hafnium, is used as a corrosion resistant material of construction in the process industries.

Reinforced Plastics Use Up in '57, Higher in '58

CONSUMPTION OF REINFORCED PLASTICS BY END USE

End Use ↓	1957 (millions of pounds)	1956 (millions of pounds)	1957—% of Volume
Aircraft and Missiles	25.2	28.0	15
Appliances	5.0	7.0	3
Boats	25.2	22.4	15
Construction	25.2	22.4	15
Consumer Products	25.2	14.0	15
Containers and Trays	5.0	7.0 (incl "Tanks, Ducts")	3
Electrical	5.0	(in "Miscellaneous")	3
Pipe, Tanks, Ducts	3.4	(in "Containers")	2
Transportation	33.6	11.2	20
Miscellaneous	15.1	28.0	9
Total	167.9	140.0	100

■ Consumption of all types of reinforced plastics was 20% higher in 1957 than it was in 1956—168,000,000 lb as compared to 140,000,000 lb—and is expected to increase by 20% again in 1958.

These figures are based on a market study conducted by the Reinforced Plastics Div., Society of the Plastics Industry, Inc. According to the study, 1958 optimism is based on expected increases in the sale of molded reinforced plastics boats; television,

(continued on p 220)

Prices of Materials

Changes since last month are bold-faced

NONMETALLICS

Prices for large quantities for range of grades, color, sizes; given in $/lb

RUBBER

Material	Dry	Latex
Butadiene-Acrylonitrile	.49-.65	.46-.54
Butadiene-Styrene	.17-.30	.22-.32
Butyl	.23-.28	—
Neoprene[a]	.39-.75	.37-.47
Silicone[a]	1.90-4	—
Polysulfide[a]	.47-1	.70-.92
Natural	**.29**[b]	—

[a] Less than carload quantities.
[b] Average spot price for month of Dec.

GLASS FOR REINFORCED PLASTICS

Fabric ($/yd 38 in. wide)[a]	
112 Woven	.48
181 Long-shaft satin weave	1.03
143 Unidirectional	1.00
Roving[a]	
Continuous	.40
Continuous spun strand	.36
Continuous chopped spun	.38
Milled fibers (1/32-¼ in.)[a]	.45
Mat	
Chopped strand (2 in.)[a,b]	.52-.72
Surfacing ($/1000 sq ft)[c]	10-19
Continuous chopped strand (¼-2 in.)	.40

[a] Price includes binder or finish.
[b] Price varies with binder.
[c] 0.010-0.020 in. thick.

THERMOSETTING PLASTICS

Material	Molding Compounds	Laminating, Casting Resins
Alkyd	.34-.53	—
Epoxy	—	.45-.80
Melamine	.42-.45	.40-.41
Phenolic	.21-.40	.17-.34
Polyester	.42	.32-.50
Silicone	2.75-5.40	1.55-1.74[a]
Urea	.19-.33	—

[a] 60% solids content.

All prices are approximate and given solely for general guidance of those responsible for materials selection.

THERMOPLASTICS

Material	Molding Compounds	Sheet (.030-.250 in.)	Rod		Tube	
			⅛-¼ in.	⅜-1¼ in.	⅛-¼ in.	⅜-1¼ in.
Acrylic	.51-.59	.49-2.15	.90-1.15	.80-.90	1-1.15	.90-1
Cellulosic						
Acetate	.36-.65	.92-1.16	.75-1	.65-.75	.85-1	.75-.85
Butyrate	.50-.72	1-1.28	.95-1.20	.85-.95	1.05-1.20	.85-1.05
Nitrate	—	1.60-2.73	1.45-1.75		2.25-5.00	
Propionate	.51-.63	—	—		—	
Fluorocarbon						
CFE	7-8	15-23	18-22	14-20	20-22.50	16-20
TFE	4.50-7.45	14.30-11	13	13	13	13
Nylon	1.18-2.30	—	3	3	3	3
Polyethylene	.35-.56	.85-1	.75-1	.65-.75	.85-1	.75-.85
Polystyrene	.26-.44	.57-.61	.65-.90	.55-.65	.75-.90	.65-.75
Vinyl	.27-.43	.62-.92	.75-1	.65-.75	.85-1	.75-.85

NONFERROUS METALS

Mill base prices for large quantities; given in $/lb except where indicated

ALUMINUM

Pig (99-99.9%)	.26-.28
Ingot (99-99.9%)	.28-.30
Foil (5-0.5 mil)	.55-.77
Alloy Ingot (13, 43, A132, 214)	.29-.32
Sheet (1100, 3003; 3-0.03 in.)[a]	.43-.47
Plate (1100, 3003, 5050, 3004, 5052)[a]	.40-.43

[a] Mill finish.

BRASS

Form	Cart., 70%	Low, 80%	Red, 85%
Sheet, Strip	.44	.47	.47
Seamless Tubing	.47	.49	.50
Rod (not f.c.)	.44	.46	.47
Wire	.45	.47	.48

COPPER

Ingot (elec)	.27
Sheet, Strip (hot rolled)	.50
Seamless Tubing	.50
Rod, Drawn	.47
Rod, Free Cutting	.57
Wire	
Round	.32
Square, Rectangular	.35
Magnet	.40

LEAD

Common Grade	**.13**

MAGNESIUM

Pig (98.8%)	.35-.36
Ingot (98.8%)	.36-.37
AZ91B Ingot (die casting)	.37
AZ91C Ingot (sand casting)	.41[a]

[a] Delivered price.

NICKEL

Form	"F"	"A"	Monel
ingot	.75[a]	—	—
Rod	—	1.07	.89
Sheet, C.R.	—	1.26	1.06
Strip, C.R.	—	1.24	1.08
Seamless Tube	—	1.57	1.29

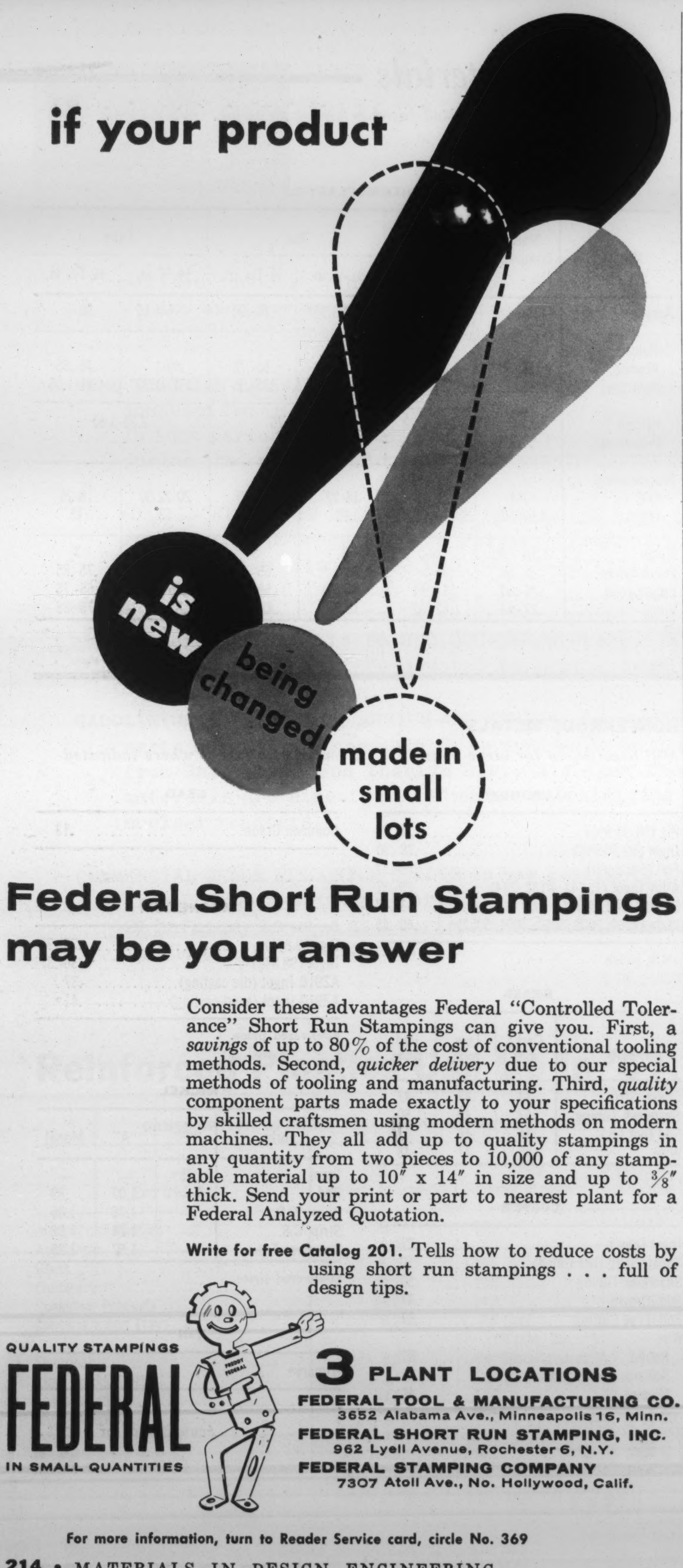
[a] Delivered price.

TIN

Primary[a]	.90

[a] Delivered price.

(continued on p 214)



Federal Short Run Stampings may be your answer

Consider these advantages Federal "Controlled Tolerance" Short Run Stampings can give you. First, a *savings* of up to 80% of the cost of conventional tooling methods. Second, *quicker delivery* due to our special methods of tooling and manufacturing. Third, *quality* component parts made exactly to your specifications by skilled craftsmen using modern methods on modern machines. They all add up to quality stampings in any quantity from two pieces to 10,000 of any stampable material up to 10″ x 14″ in size and up to 3/8″ thick. Send your print or part to nearest plant for a Federal Analyzed Quotation.

Write for free Catalog 201. Tells how to reduce costs by using short run stampings . . . full of design tips.

QUALITY STAMPINGS
FEDERAL
IN SMALL QUANTITIES

3 PLANT LOCATIONS

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FEDERAL SHORT RUN STAMPING, INC.
962 Lyell Avenue, Rochester 6, N.Y.
FEDERAL STAMPING COMPANY
7307 Atoll Ave., No. Hollywood, Calif.

For more information, turn to Reader Service card, circle No. 369

PRICES AND SUPPLY

TITANIUM

Sponge (99.3+%)	1.65-2.50
Bars, Rod	6.15-6.40
Plate	8.00-10.75
Sheet, Strip	9.50-11.10
Wire	7.50-8.00

ZINC

Prime Western	.10½ [b]
Die Casting Alloys [a]	.14-.15
Sheet	.24
Ribbon	.21
Plates	.19

[a] Alloys 2, 3, 5. [b] Delivered price.

METAL POWDERS

Aluminum [a,b]	.40
Brass [a]	.31-.38
Copper (elec or red.) [a]	.41
Molybdenum (98%)	3.80-4.10
Nickel	1.05
Tantalum	49
Tungsten (C-red. 98.8%; H_2-red. 99+%)	3-4 [c]
Zirconium	
Flash Grade	11.50
Electronics Grade	15

[a] Price for −100 mesh. [c] Delivered price.
[b] Freight allowed.

OTHER NONFERROUS METALS

Cadmium (bars)	1.55
Columbium	55-85
Gold	$35/troy oz
Indium (99.97+%)	$2.25/troy oz
Manganese (99.9%)	.34 [a]
Palladium	$23-24/troy oz
Platinum	$77-80/troy oz
Silver	91¢/troy oz
Tantalum (sheet, rod)	55-60
Vanadium	80
Zirconium (sheet, strip, bar)	25-35

[a] Delivered price.

IRONS AND STEELS

Mill base prices for large quantities

SEMIFINISHED STEEL ($/net ton)

Ingots, Alloy	77
Billets, Blooms, Slabs	
Carbon, Re-Rolling	77.50
Carbon, Forging	96
Alloy, Forging	114
Seamless Tube Rounds	117.50
Wire Rods	$6.15/cwt

(continued on p 216)

Hydroforming

a deep drawing and forming service without costly dies

saves up to 90% on tooling costs... speeds model development work... allows unequalled design freedom... saves on short and medium production runs.

These parts are typical of the hundreds of parts of all shapes and complexities that have been produced by the Hydroforming Company of America. This versatile, economical form of simplified deep drawing combines extreme precision in deep drawing with low cost tooling and fast parts delivery. While showing to its best advantage on medium and smaller production runs, **it can and does** produce parts that are impossible to produce by any other method.

Hydroforming can often produce spectacular results in forming prefinished parts—reducing delivery times—cutting costs. One manufacturer cut production time **by 90 days and reduced tooling costs over $30,000.00.**

Do you have a part that can be Hydroformed?

Write, wire or call for details, or send your prints for estimates—in strictest confidence of course.

Hydroforming Company of America

7406 W. Lawrence Ave., Chicago 31, Illinois PHONE: UNderhill 7-7600

For more information, turn to Reader Service card, circle No. 400

DESIGN *for* SALES

Trim parts play a very important part in making that final sale to the ultimate consumer. Most important are; Appearance and Cost!

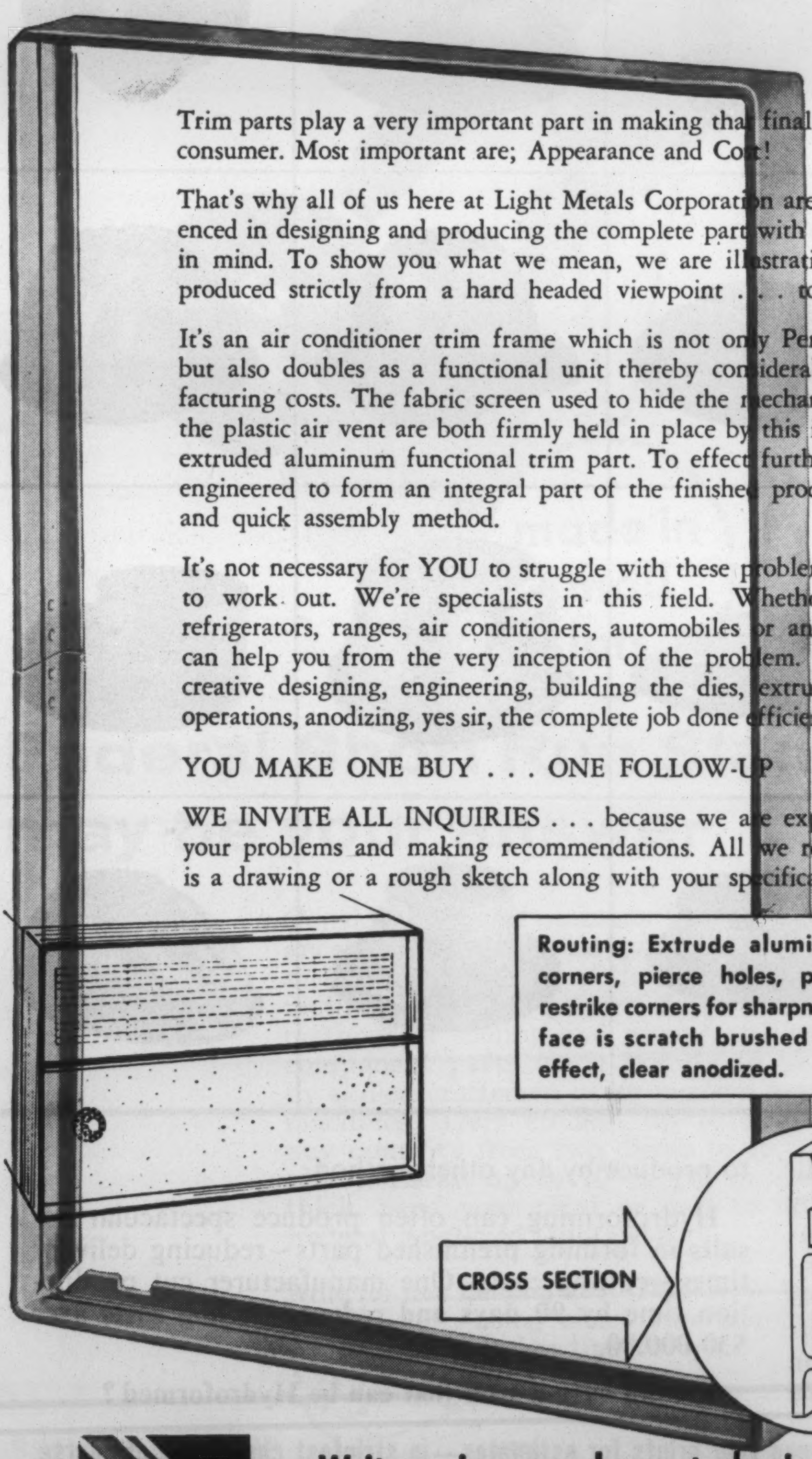
That's why all of us here at Light Metals Corporation are trained and experienced in designing and producing the complete part with our customer's Sales in mind. To show you what we mean, we are illustrating a part that was produced strictly from a hard headed viewpoint . . . to help gain SALES.

It's an air conditioner trim frame which is not only Permanently Beautiful, but also doubles as a functional unit thereby considerably reducing manufacturing costs. The fabric screen used to hide the mechanism from view and the plastic air vent are both firmly held in place by this ingeniously designed extruded aluminum functional trim part. To effect further economies it was engineered to form an integral part of the finished product via a very easy and quick assembly method.

It's not necessary for YOU to struggle with these problems. Give them to us to work out. We're specialists in this field. Whether you manufacture refrigerators, ranges, air conditioners, automobiles or any other product, we can help you from the very inception of the problem. Our service includes creative designing, engineering, building the dies, extruding, all fabricating operations, anodizing, yes sir, the complete job done efficiently in our one plant.

YOU MAKE ONE BUY . . . ONE FOLLOW-UP

WE INVITE ALL INQUIRIES . . . because we are experts in working out your problems and making recommendations. All we require to work with is a drawing or a rough sketch along with your specifications.


Routing: Extrude aluminum, notch corners, pierce holes, pact formed, restrike corners for sharpness, exposed face is scratch brushed for desired effect, clear anodized.
CROSS SECTION

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LMC

LIGHT METALS CORPORATION

1217 Monroe N.W. Grand Rapids 5, Michigan

EXTRUDED ALUMINUM - COMPLETE FABRICATION FACILITIES - ANODIZING

For more information, turn to Reader Service card, circle No. 467

PRICES AND SUPPLY

FINISHED STEEL ($/cwt)

Form	Carbon	High Str Low Alloy	Alloy
Plate	5.10	7.62	7.20
Sheet, H.R.	4.92	7.27	—
Sheet, C.R.	6.05	8.97	—
Strip, H.R.	4.92	7.32	8.10
Strip, C.R.	7.15	10.65	—
Bar, H.R.	5.42	7.92	6.47
Bar, C.F.	7.30	—	8.77

STAINLESS STEELS ($/lb)

Material	Forging Billets	H. R. Bars	Plate	Sheet, Strip
Austenitic				
301, 302, 302B, 303, 304, 305	.38-.41	.44-.48	.46-.51	.51-.59
321[a]	.47	.56	.60	.66
347[a]	.56	.65	.70	.80
Martensitic				
410[a]	.28	.34	.35	.40
416	.29	.34	.35	.47
403	.32	.38	.40	.48
420, 440	.34	.41	.45	.62
Ferritic				
405, 430, 430F[a]	.30	.34-.35	.36-.38	.41-.47
442	.32	.38	.40	.56
431	.30	.35	.46	.54
446	.38	.45	.46	.67
High Mn				
202[a]	.37	.43	.45	.49
Extra Low C				
304L	.48	.56	.59	.63
316L	.70	.81	.85	.89
Precip Hard.				
17-7PH	.66	.73	.85	.90
PH 15-7 Mo	**.86**	**.93**	**1.11**	**1.16**

[a] Ingot price approx 60% of billet price.

METAL POWDERS ($/lb)[a]

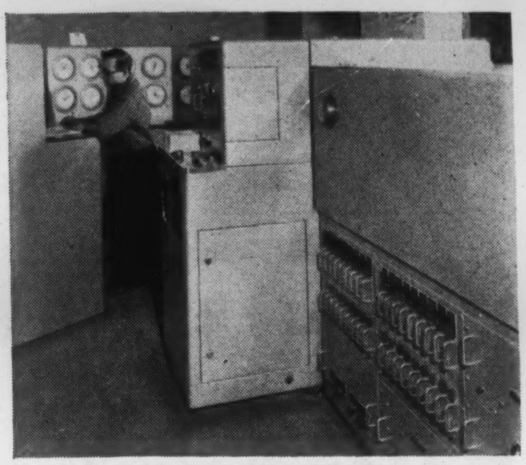
Sponge Iron	.10-.11
Electrolytic Iron	
Annealed (99.5%)	.37
Unannealed (99+%)	.36
Stainless Steel	
304	1.02
316	1.20

[a] Price for —100 mesh.

IRON ($/gross ton)

Pig	65-66

(continued on p 218)



A spectrometer checks every heat. Changes can be made before metal is poured.

When you have a galling problem in metal-to-metal contact ☐

or galling and corrosion-resistant problems ☐

investigate castings made with

Waukesha

metal 23* or 88*

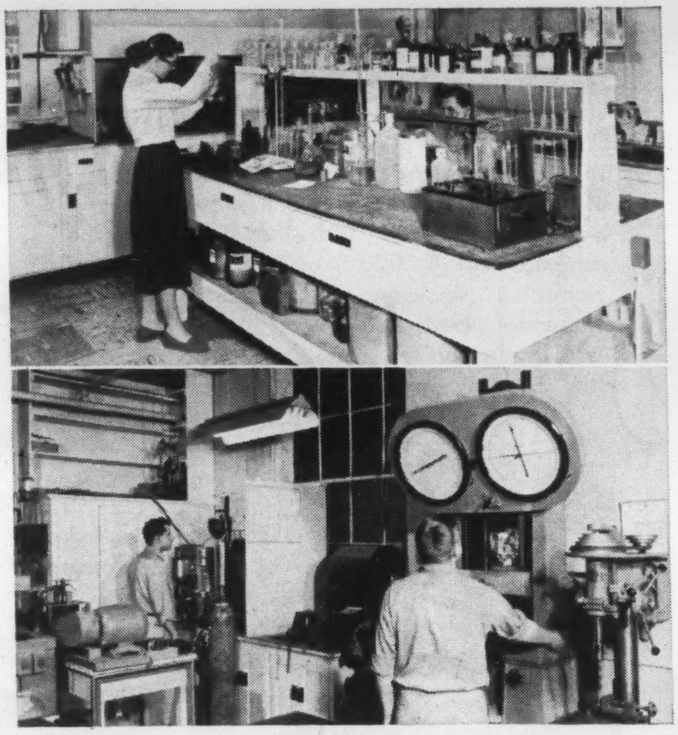
Perhaps you've tried heat treating 400 Series stainless steel alloys to solve your galling difficulties . . . and found the metal has become so hard it can't be machined. Or perhaps serious distortion occurs.

Perhaps you've tried various other alloys and found they don't measure up for *every* performance requirement . . . Either non-galling characteristics or high corrosion resistance are difficult problems separately. Combined they are an impressive engineering headache.

But WAUKESHA Metal 23 or 88 provides non-galling performance even under high speed metal-to-metal contact AND both are highly corrosive-resistant. Both are remarkably free-machining, without hard or soft spots. Both are homogeneous in texture.

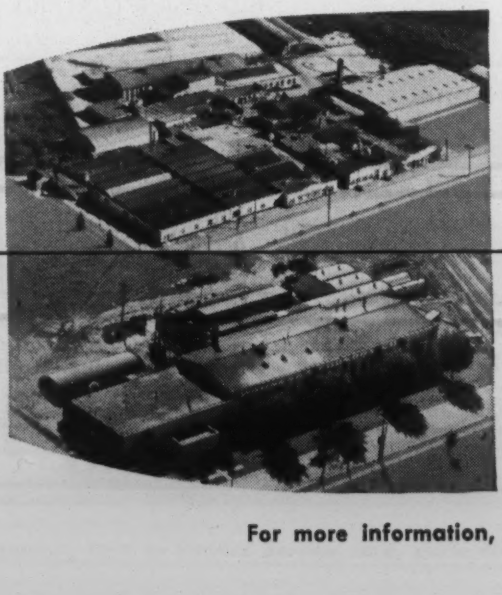
WAUKESHA 23 and 88 have solved many of the most difficult casting problems in a great range of industries. We're glad to supply you with a list.

Or better still, write us. Describe your problems and the conditions which must be met. More than likely we'll have the answer for you.



Two views of the Waukesha Metalurgical Laboratory — one of the most complete in the country.

* *So unusual and different are WAUKESHA Metals 23 and 88 that patents have been granted on both formulations.*



Waukesha Plant

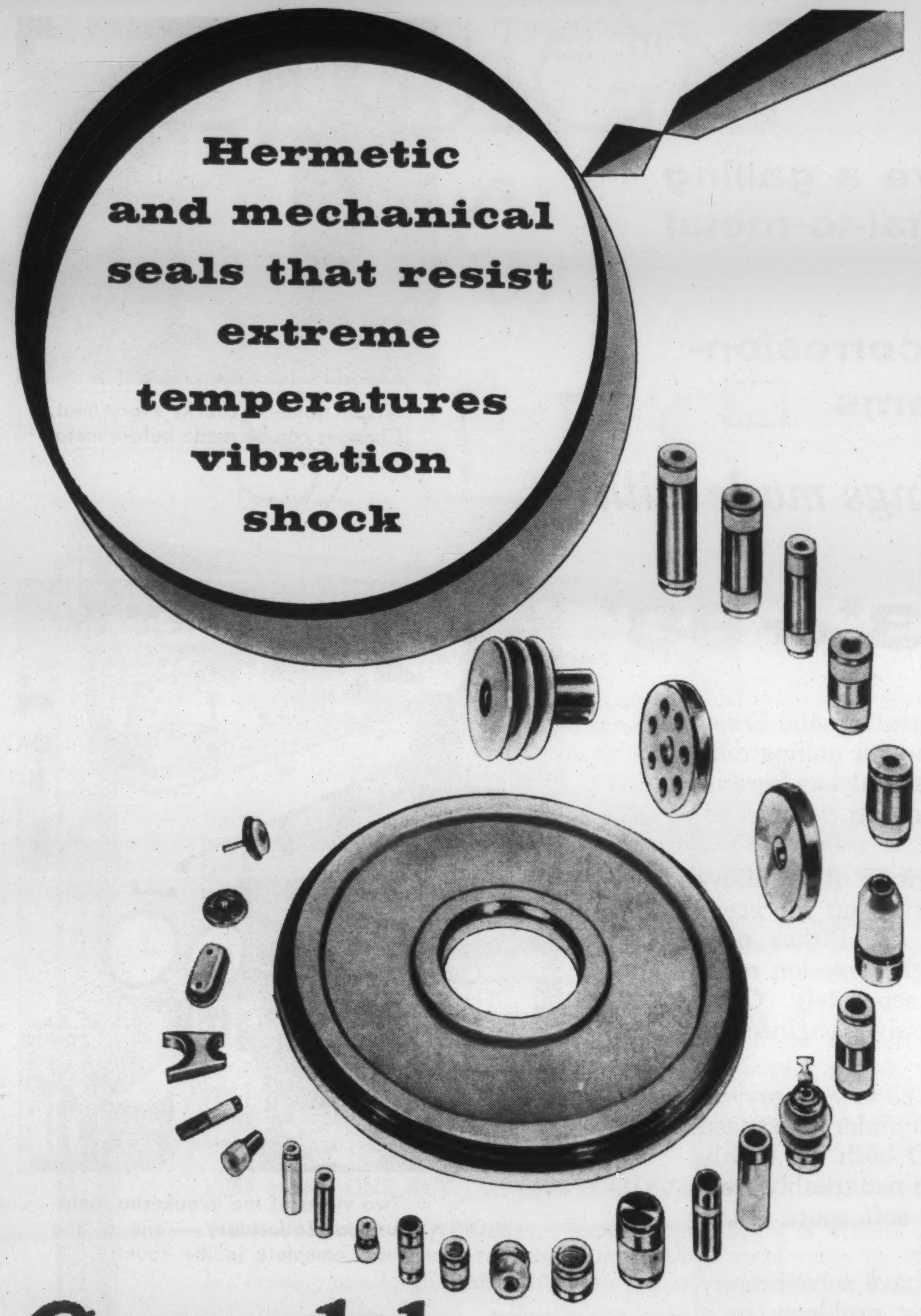
Watertown (Wis.) Plant

Waukesha

FOUNDRY COMPANY

5804 LINCOLN AVE. • WAUKESHA, WISCONSIN

For more information, turn to Reader Service card, circle No. 514



Centralab

metalized high alumina ceramics

Exceptional metal-ceramic bond strength (withstands 4000 psi pull) combined with the outstanding physical and electrical stability of Centralab High Alumina—results in a product that can provide the solution to many of your military and commercial reliability problems.

Centralab's 30 years' experience in engineered ceramics, plus newly expanded production facilities, provide a fast, dependable source for High Alumina and Steatite ceramics. These can be supplied with or without metalized surfaces.

Write for the new Centralab Engineered Ceramic Design Catalog 42-221 or consult Sweet's Product Design File (folio 4 a/ce).

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VARIABLE RESISTORS • PACKAGED ELECTRONIC CIRCUITS • ELECTRONIC SWITCHES
CERAMIC CAPACITORS • ENGINEERED CERAMICS • SEMI-CONDUCTOR PRODUCTS

For more information, turn to Reader Service card, circle No. 524

CLAD STEELS (¢/lb)[a]

Cladding Metal	10%	15%	20%
Stainless			
304	38	42	47
304L	41	45	50
316L	49	55	60
321	40	45	49
347	42	48	53
430	30	33	37
Inconel	60	70	81
Nickel	52	62	73
Monel	54	64	74

[a] Prices given for three cladding thicknesses.

TIN PLATE ($/base box)

Hot Dip (1.25-1.50 lb)	10.05-10.30
Electrolytic (0.25-0.75 lb)	8.75- 9.40

FINISHES AND COATINGS

ORGANIC COATINGS

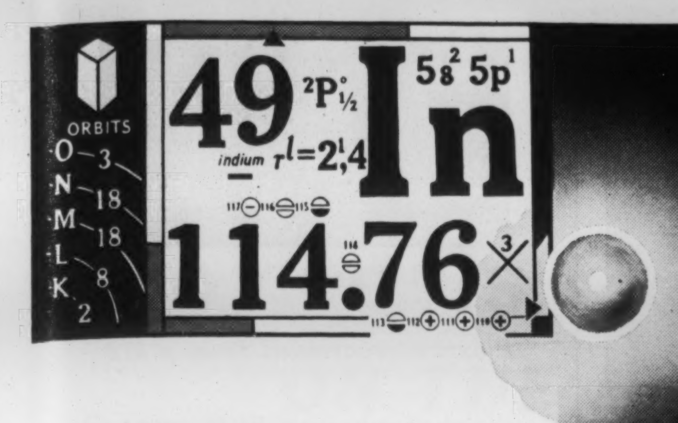
Material	Avg Thk per Coat, mil	Mils Required[a]	Cost, ¢/sq ft/dry mil[b]
VARNISHES, ENAMELS			
Short Oil Phenolic			
Varnish	1.0	1.0	1.5
Enamel	1.2	1.0	1.75
100% Phenolic	1.0	1.5	1.75
Straight Oil-Modified			
Alkyd	1.5	1.5	1.5
Alkyd-Amine (90-10)	1.5	1.5	1.75
Alkyd-Phenolic (50-50)	1.5	1.5	1.75
Alkyd-Vinyl (50-50)	1.0	2.0	2.0
Alkyd-Styrene (70-30)	1.2	1.5	1.75
Epoxy	1.8	1.8	2.0
Silicone	.5-1.0	.5-1.0	6.0
Furane	2.0	2.0	1.0
Neoprene	5.0	5.0	1.5
DISPERSION COATINGS			
Phenolic	1.0	1.5	1.75
Vinyl	1.0	2.0	2.5
Fluorocarbon	1.0	1.0	15.0
LACQUERS			
Nitrocellulose	1.0	2.0	2.5
Vinyl	1.0	2.0	2.5
Acrylic	1.0	2.0	2.75
Butyrate	1.0	2.0	2.75

[a] Thickness over phosphate coating required for exterior durability on steel. For purely decorative coating. 1 mil will usually suffice.

[b] Materials cost only. Realistic price comparison can be made only on basis of dry applied coating, not on basis of cost per gallon.

(news on p 220)

For more information, turn to Reader Service card, circle No. 399



INDIUM *has properties which you may need*

- Resists corrosion
- Aids lubrication
- Unique stabilization

Commercial quantities are available in Indium metal (specially refined 99.999% pure or 99.97% pure), Indium wire, foil, ribbon, pellets, spheres or powders. Also "Indalloy" intermediate solders and other high-purity metals.

Write Dept. M-2 for new Indium bulletin: *"INDALLY Intermediate Solders"*

QUALITY
SERVICE
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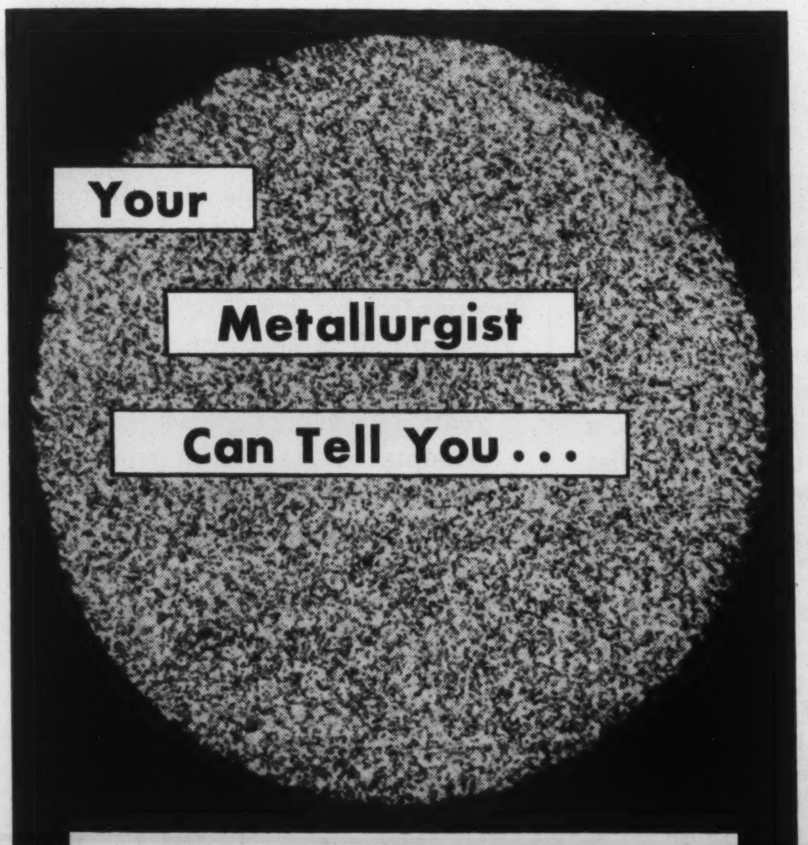
THE **INDIUM** CORPORATION OF AMERICA
1676 Lincoln Avenue • Utica, New York
Since 1934 . . . Pioneers in the Development and Applications of Indium for Industry



. . . why Webb works where others won't. A lot of the answer is in this photomicrograph of Webb Needle Wire. The concentricity, complete spheroidization and freedom from decarburization shown above spell big fabrication and performance benefits for you.

WEBB WIRE
Division of The
CARPENTER STEEL CO.
New Brunswick, N. J.

For more information, turn to Reader Service card, circle No. 368

for extreme temperatures

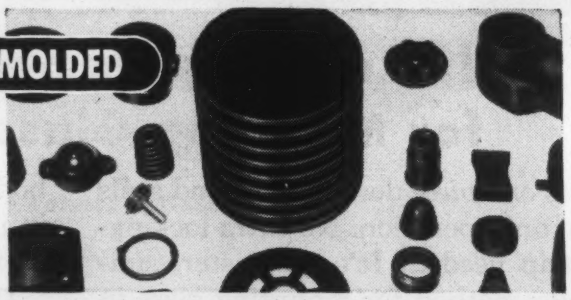
SILICONE

RUBBER PARTS AND COMPONENTS BY

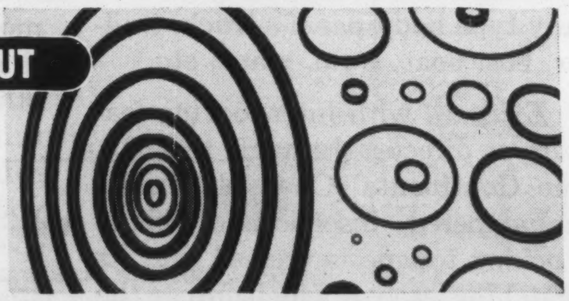
Goshen Rubber

Goshen-developed silicone rubber compounds offer properties like resistance to temperature extremes −80 to +500° F; resiliency over a range of −120° F to +600° F; low compression set; resistance to chemicals, oxidation, ozone, moisture, corrosion, shock, abrasion; freedom from stain, odor, tackiness and toxicity; same shrinkage as organic rubber, with resultant advantages.

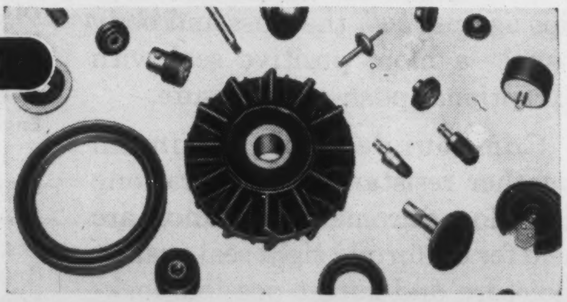
CUSTOM MOLDED



LATHE CUT



BONDED

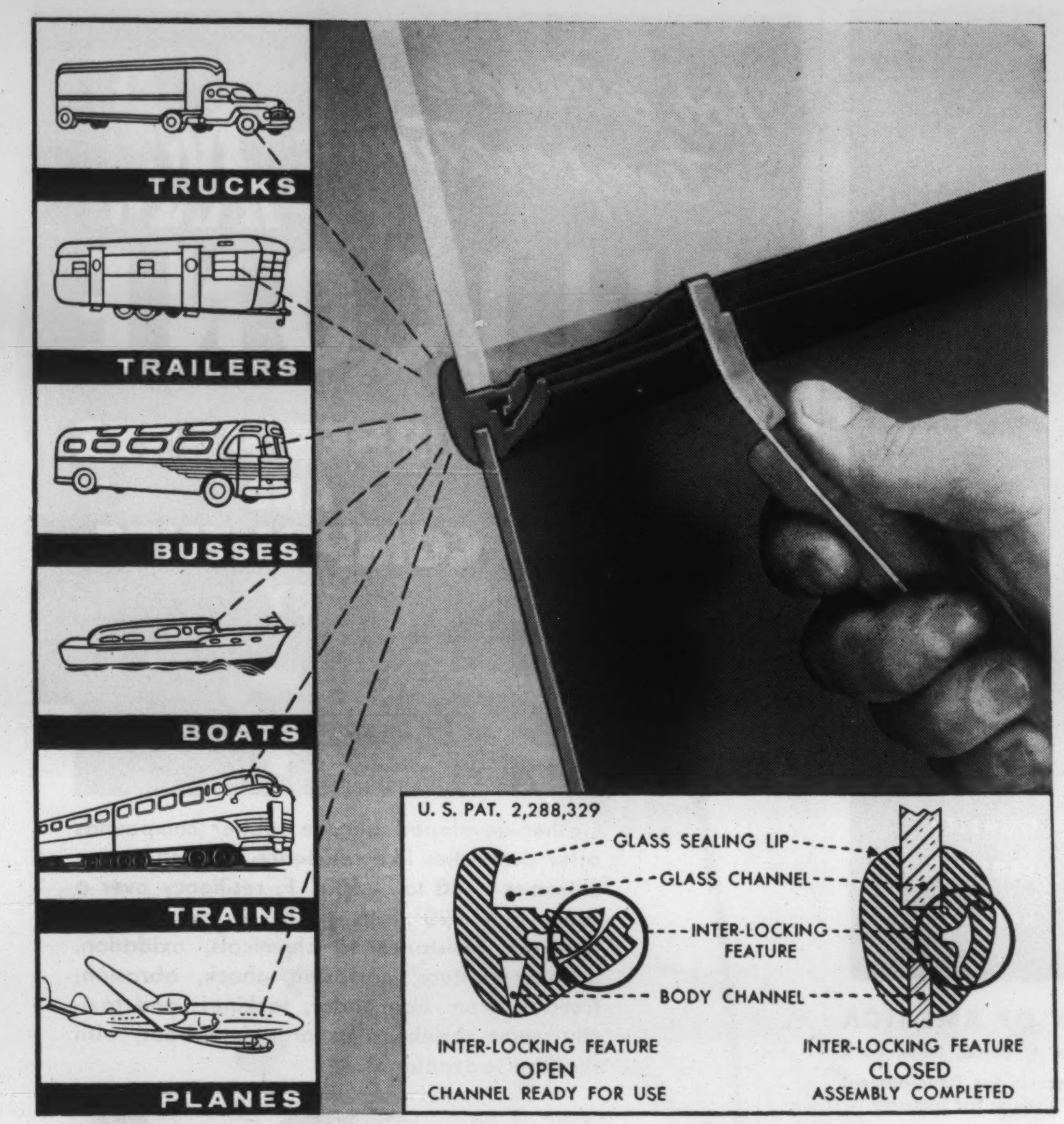


QUALITY ENGINEERED RUBBER PRODUCTS

GORSIL compounds are now available for adaptation to your next part problem that involves temperature.

Goshen Rubber Co., INC.
3128 S. TENTH ST. GOSHEN, INDIANA

For more information, turn to Reader Service card, circle No. 493



Self-Locking Rubber Channel for Mounting Glass in Body Panels

Its *one-piece* design locks and seals in one operation. No extra locking-strip needed. It's the faster, simpler method for mounting glass in any type body panel—truck, trailer, bus, boat, train, plane, etc.

Extruded with inter-locking feature at direct right angle to body, the Continental Channel permits unhampered insertion of glass. Locking tongue is pressed into its matching groove which forces the lips against *both* the glass and body panel—a more positive seal with exceptional push-out pressure.

Compounded for maximum weather resistance and extra long life. Close durometer tolerances are held for uniformly tight seal against moisture and surest possible locking. These rubber channels can be positioned first on *either* glass or body panel. All details are shown in illustrated brochure gladly sent on request.

Ordered and re-ordered by the most prominent body builders, this Self-Locking Channel is another example of the creative thinking and ingenuity behind rubber parts by Continental. When you need rubber parts to do a specific job, call a rubber specialist *during the planning stage.* This often makes for economy as well as better end results. Call Continental—rubber specialists since 1903.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
engineered by **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1985 LIBERTY ST. • ERIE 6 • PENNSYLVANIA

For more information, turn to Reader Service card, circle No. 461

Plastics—continued from p 212

phonograph and hi-fi sets; automobile components; and public seating.

A breakdown of the 168,000,000-lb consumption figure shows that resins accounted for 84,000,000 lb of the total; reinforcement, filler, pigment, etc., accounted for the remaining 84,000,000 lb. Of the resins, polyesters far outweigh any of the others, accounting for 78,000,000 lb. A breakdown of end uses comparing 1957 with 1956 is given in the accompanying table (p 212).

West Needs More Steel; Kaiser Doubles Output

The Western section of the United States consistently consumes more steel than is produced by Western mills, according to a report issued by Kaiser Steel Corp. As a result, Kaiser has decided to double production at its Fontana, Calif. plant.

According to the report, consumption of steel in the West is continually increasing, and it is estimated that 1957 was a record year. The report states that gross receipts of steel mill products in the seven Western states for 1956 was a record 6,840,000 net tons, surpassing the previous high of 6,352,000 tons established in 1955. During the first six months of

WESTERN CONSUMPTION OF STEEL BY MILL PRODUCTS
(1000 Net Tons)

Product ↓	1956	1955
Plate	1043	921
Sheet, Strip	1295	1224
Structural Shapes	594	477
Bars	1089	1019
Standard and Line Pipe (½-12¾ in.)	557	572
Tin Mill Products	1150	1061
Other	1112	1078
Total	6840	6352

YOLOY "E" IS ON THE JOB

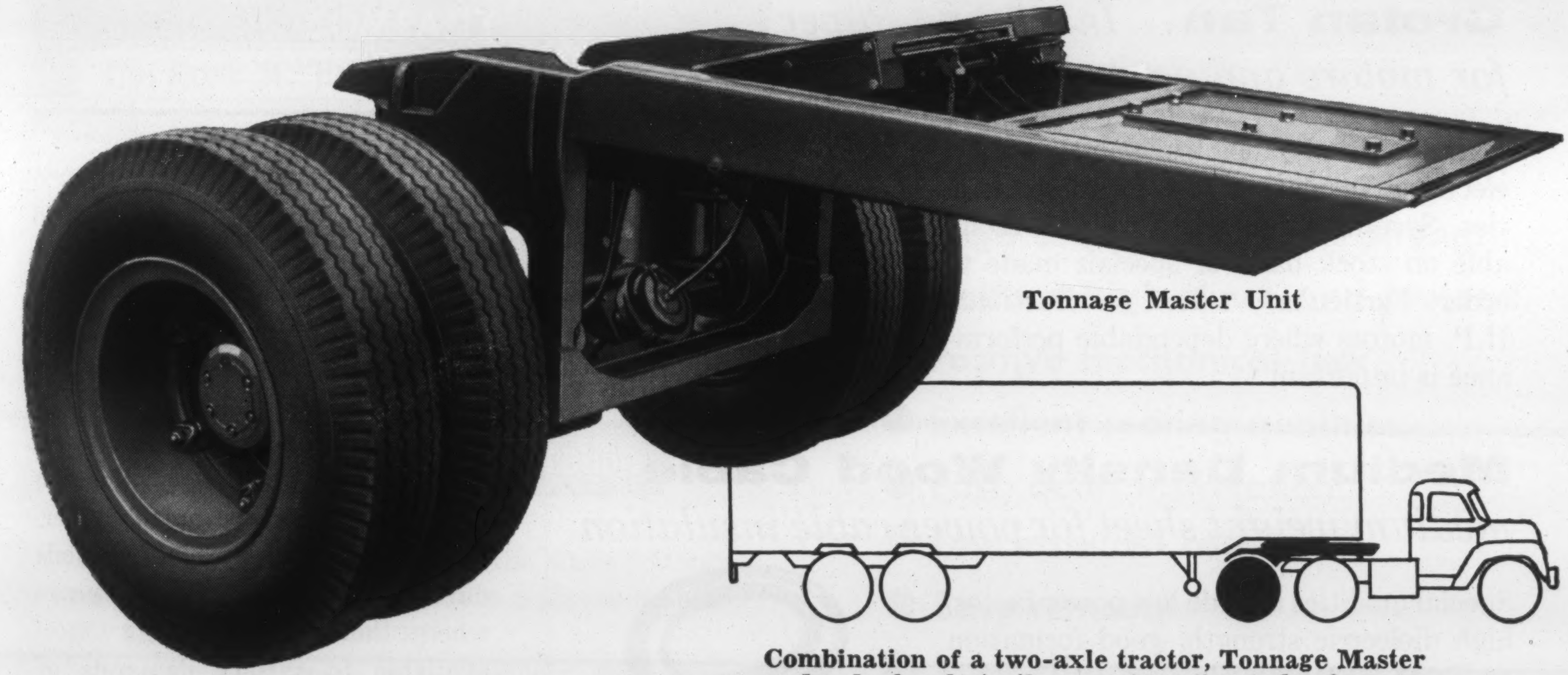
. . . providing increased strength, corrosion and impact resistance for Fruehauf's new "Tonnage Master"

This "extra axle" conversion assembly, built exclusively by Calumet Tonnage Master Fabricators, Inc., for the Fruehauf Trailer Company, enables truck operators to get maximum performance from their existing equipment.

Riding behind a two-axle tractor, a Tonnage Master provides increased load carrying capacity, reduction in tractor wheelbase, improved traction on curves, increased tire life as well as easier riding through utilization of more springs.

All components—except springs and axles—are fabricated from Youngstown's Yoloy "E" high strength-low alloy steel. This versatile steel was wisely specified to provide the units with longer life, increased resistance to shock, vibration and corrosion, as well as lighter—yet stronger—construction.

Youngstown's complete family of Yoloy steels is available in Sheets, Plates, Bars, Shapes, Cold Drawn Bars and Tubular Products. Complete informative Data Sheets on each Yoloy steel will be promptly sent upon request.



Tonnage Master Unit

Combination of a two-axle tractor, Tonnage Master and a dual-axle trailer provides five axles for carrying top loads at greater safety.

Write for these free pamphlets in The Yoloy Family series:

YOLOY "E"	High Strength Low Alloy Steel—standard applications
YOLOY	High Strength Low Alloy Steel—special applications
YOLOY "S"	Higher Strength Steel for increased service life
YOLOY "C"	Corrosion Resistant Grade for deep forming
YOLOY PIPE	Continuous Weld for corrosion resistant applications

THE YOUNGSTOWN SHEET AND TUBE COMPANY
Manufacturers of Carbon, Alloy and Yoloy Steel
General Offices - Youngstown 1, Ohio
District Sales Offices in Principal Cities

For more information, turn to Reader Service card, circle No. 413

NEWS and DATA
ON TECHNICAL PAPERS FOR
Insulation!

Creped Insulating Kraft... *high strength Insulating Paper*

Special machine treatment gives unusual stretch for a primary crepe — 50% in a 53 lb. basis weight. Caliper is .015. Excellent insulation for telephone cable, electronic and electrical wire and of interest to converters requiring high percentage crepe.

Grotan Tan... *Insulating Paper for motors and generators*

Extreme density (17 lbs/point), purity, electrical insulating and forming qualities. Several weights and calipers available on stock basis or specials made to order. Particularly suited for fractional H.P. motors where dependable performance is important.

Medium Density Wood Cable... *medium weight sheet for power cable insulation*

Special qualities include low power factor, high dielectric strength, good formation and high length tensile.

SEND FOR COMPLETE DATA SHEETS.

Also, many types of standard and special papers for insulating, using world-wide selection of fibers to attain optimum strength, cleanliness, and power factor. Write today.

HOLLINGSWORTH & VOSE
COMPANY
EAST WALPOLE, MASSACHUSETTS
PIONEER DEVELOPERS OF SPECIAL PURPOSE MULTI-FIBERED PAPERS

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What Happened to Materials Prices in 1957

($/lb except where indicated)

Material ↓	Jan	June	Dec
Aluminum	.25	.25	.26
Copper	.36	.32	.27
Iron[a]	62.50-63.50	64.50-65.50	65-66
Lead	.16	.155	.135
Natural Rubber	.37	.33	.28
Nylon	1.35	1.35	1.18
Phenolic	.20	.20	.21
Polyethylene	.37	.37	.35
Polystyrene	.27	.27	.26
Steel[b]	.74	.74	.75
Tin	1.09	1.99	.90
Titanium	2.50	2.00	1.65
Zinc	.13-.14	.11-.12	.105

[a] $/gross ton. [b] $/net ton.

1957, the Western section used more steel than it did any other six month period, and indications are that the final figures for the year will show a total consumption of seven million tons.

A large portion of this steel, however, comes from Eastern mills. In fact, according to Kaiser, there were only two brief periods during the last 10 or 15 years when there was enough steel available to satisfy demands of consumers in the West; Western mills operating at capacity have only been able to provide just over one half of the steel needs of this area. As a result, Kaiser has initiated a $194 million expansion program aimed at doubling its output of plate, sheet, structurals and tinplate at its Fontana plant.

Although consumption of steel in this area is expected to stay at high levels, Kaiser feels that its new expansion, to be completed early in 1958, will materially aid steel consumers.

(Other News on p 224)

For more information, turn to Reader Service card, circle No. 501

Bronze

"Controlled" CASTINGS

for ENGINEERING and CHEMICAL PURPOSES

By "controlled" we mean that every step in alloying, molding, pouring and cooling is under *careful supervision* of trained men *in our own plant*. . . . So, if you require non-ferrous castings (large or small) to meet any of the following conditions, you are safe in bringing your problems to us: Corrosion Resistance; Strength in Tension and Compression; Hardness and Toughness; Pressure Tightness; Erosion Resistance; Frictional Wear Resistance or Fatigue Resistance.

Would you like a copy of our famous 48 page flexible-bound Reference Book entitled, "*Bronze Casting Alloys*"? If so, write us on your business letterhead.

AMERICAN MANGANESE BRONZE
COMPANY
4704 Rhawn St., Holmesburg, Philadelphia 36, Pa.
ESTABLISHED 1909

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alumina ceramics

for abrasive resistant applications

There is literally no end to the ways you can use Frenchtown alumina ceramics in abrasive resistant applications. For example:

Nozzles: Sand, steam slurry, recoilless rifle, rocket, and particle classifiers.

Guides: Thread, wire, rope.

Dies: Ceramic extrusion, plastic injection molding, tablet pressing.

Pumps: Plungers, impellers, case plates, valves.

Gages: Plug, wear plates on measuring equipment.

Our newly designed and installed equipment permits us to offer a wide variety of shapes, sizes and configurations, in any quantities and at low cost. Write for complete details and descriptive literature.

frenchtown PORCELAIN COMPANY
FRENCHTOWN, NEW JERSEY

For more information, turn to Reader Service card, circle No. 414

---

up to 70% SAVING in assembly cost with HUCKBOLT FASTENERS

check these features:

- High shear and tensile strength.
- Uniform high clinch and preload.
- Positive mechanical lock.
- Excellent sealing qualities.
- Fast, quiet installation.
- Low installed cost.
- Easy removal.
- Your choice of materials and head styles.

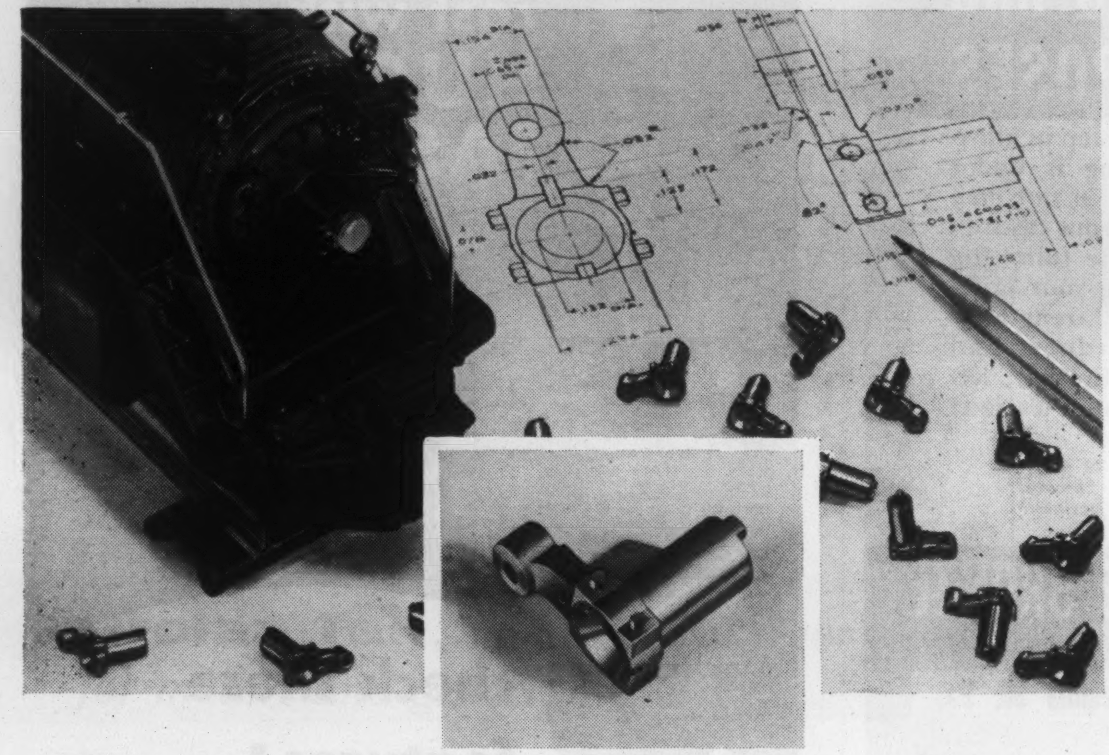
Huck fasteners offer you maximum uniform strength, high production, quiet application at advantageously low installed cost. There is a HUCK fastener to fill your need. Write for our condensed Commercial Catalog (No. 8-414) or a HUCK Fastener Consultant will call at your request.

HUCK *MANUFACTURING COMPANY*
2480 Bellevue Ave • Detroit 7, Mich.
Phone WAlnut 1-6207

For more information, turn to Reader Service card, circle No. 383

GRC DIE CASTING HELPS LIONEL ACHIEVE TINY PART AUTHENTICITY

Tiny, intricate, too costly to make in their own plant, GRC's specialized techniques made this toy crank economically possible

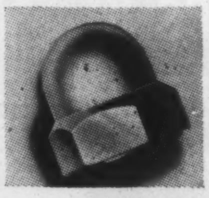


While it would seem more advantageous for manufacturers to make all parts in their own plants, some have found that a specialist can do it cheaper, faster, and sometimes even better. This Lionel toy crank is an example. GRC specialized techniques made it possible for them to produce this tiny authentic part more quickly and more economically than Lionel could themselves. Die cast in zinc alloy in a single automatic operation, the cost of the GRC crank was little more than $5.00 per thousand in lots of 500,000.

Miniature in size, intricate in shape, the crank has, for example, four subminiature hex nuts measuring .045" across the flats. It is typical of the many small parts problems solved by GRC, who specializes in parts "no bigger than your thumbnail". It is typical too of the close tolerances, clean edges and great accuracy achieved by Gries' methods. Whether simple or complex, quality is uniform—no secondary operations, no scrap loss. GRC delivered parts are ready for immediate use.

The world's foremost producer of small die castings, Gries' exclusive patented methods have resulted in many production economies and give broad flexibility in design. ***If you have a small parts problem, write for Gries' informative die casting bulletin or send prints for quotations.*** There is no minimum size; maximum, 1¾" long, ½ oz.

GRC High Series Cap Nuts Now Cataloged In Stock



Never before available to industry as a stock item from any supplier, GRC is now stocking for prompt delivery cap nuts with up to 50% greater thread depth. Immediate shipment can be made on a complete range of hex sizes from 5/16" to ⅝". Die cast in zinc alloy with long, clean thread sections, the overall height of the cap nut is well proportioned between the hexagonal section and the dome of the fastener. Protective, neat and attractive, they are rustproof, corrosion-resistant, nonferrous, without tool marks or cut-off burrs. They have a naturally bright finish and if required any standard finish can be applied. Other GRC stock fasteners include wing nuts and screws, round head thumb nuts and screws, standard cap nuts, rivets and others. ***Catalog and spec sheets on the new high series cap nuts and other fastenings are available on request.***

WORLD'S FOREMOST
PRODUCER OF SMALL
DIE CASTINGS

GRIES

GRIES REPRODUCER CORP.
153 Beechwood Ave., New Rochelle, N. Y. • New Rochelle, 3-8600

For more information, turn to Reader Service card, circle No. 466

PRICES AND SUPPLY

Other News . . .

- Bakelite Co. has discontinued production of polyester resins. The company will concentrate on epoxies and phenolics for use in reinforced plastics.

- Kaiser Aluminum & Chemical Corp. has added a ninth potline at its Chalmette, La. reduction plant. The new facility will increase primary aluminum capacity from 220,500 tons per year to 247,500 tons.

- American Potash & Chemical Corp. has begun production of a series of rubidium and cesium chemicals for use in the manufacture of glass, photocells, etc. The chemicals will be priced at $13 to $27.50 per lb, as contrasted with current prices ranging between $100 to $400 per lb.

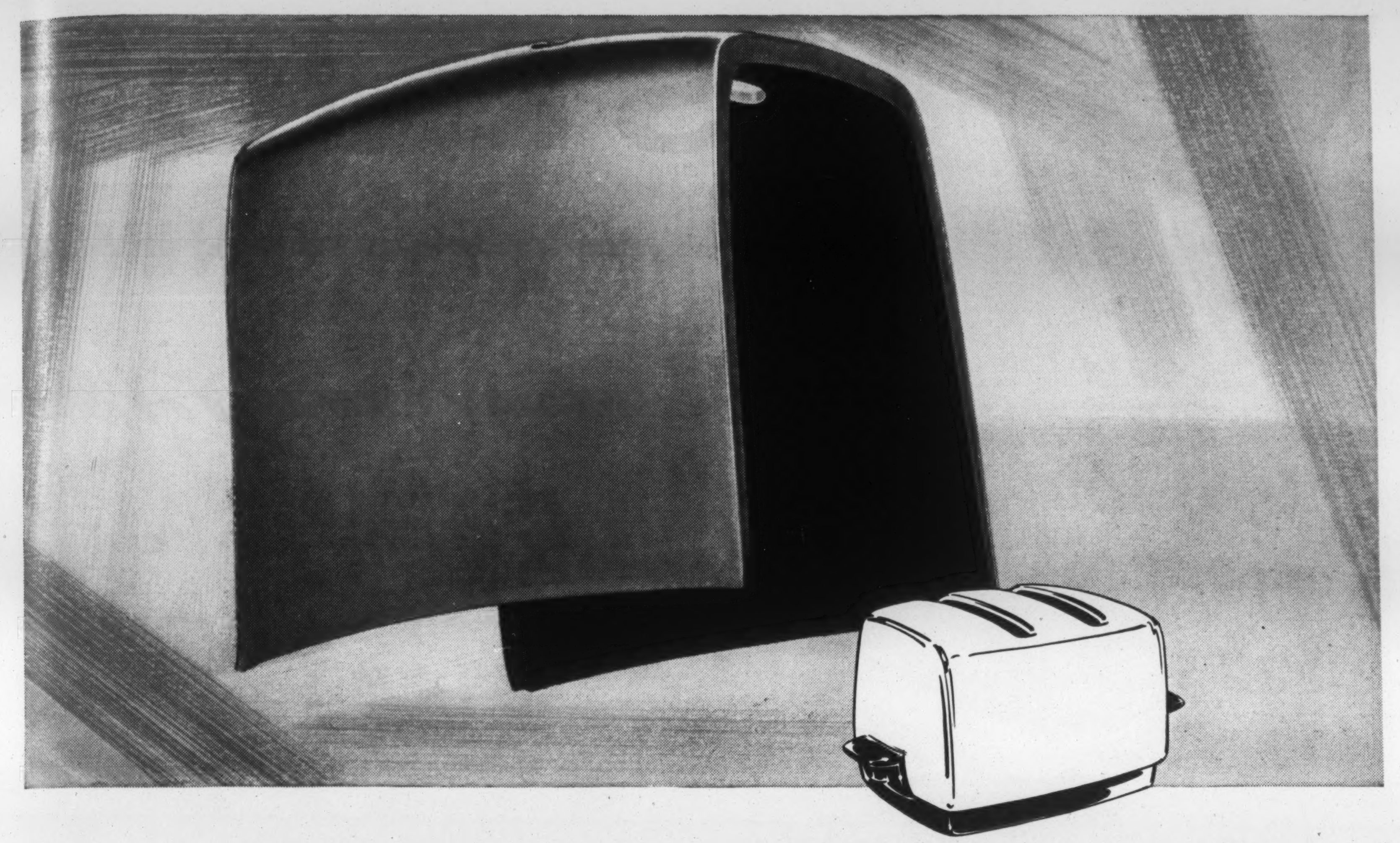
- Republic Steel Corp. has revived production of terne plate at its Warren, Ohio plant. Initial schedules call for a monthly output of 1000 tons of coils or cut lengths.

- Richardson Co. has increased production capacity of its Insurok industrial laminated plastics sheets by 100,000 lb per month.

- Brush Beryllium Co. has started operations at its new Elmore, Ohio plant. It will produce 10,000 lb per month of vacuum cast beryllium ingots.

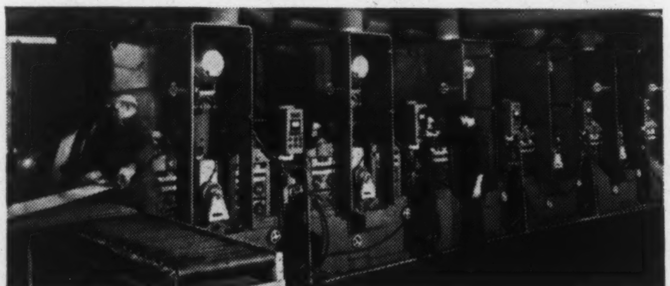
- International Nickel Co. plans a 100,000,000 lb increase in nickel production by 1961. By then, free world production capacity will be at a yearly rate of 650-675,000,000 lb, or more than twice as much as was available in 1956.

SOURCES of most engineering materials can be found in M/DE's *Materials Selector* reference issue, published last September. Properties of all materials are also given.

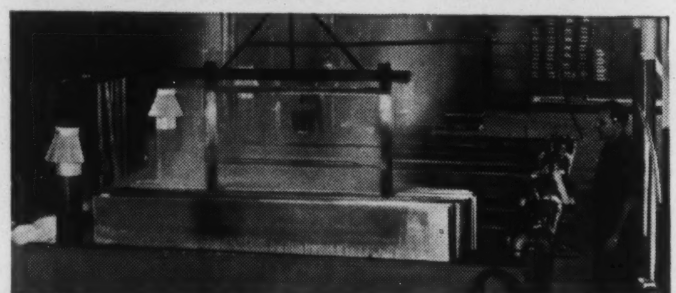


Form flat-polished metal without marring!

Use Bonderite and Bonderlube



Multiple head flat polishing at Production Finishing Corporation, Detroit.



Polished sheets are treated with Bonderite and Bonderlube before forming.

Bonderite and Bonderlube protect that smooth, flat-polished finish through forming and fabricating. Parts go direct to the plating bath from forming operations with only a light buffing.

All types of products are being made this way—automobile bumpers, automotive trim, toaster and small appliance bodies, home laundry equipment components and many other formed parts.

Cost reductions are big with Bonderite and Bonderlube: Polishing costs on bumpers went from 9c a square foot for contour polishing to 0.8c a square foot for flat polishing before forming. Savings of 10c to 30c a square foot have been reported by other industries.

The Parker technical representative has full information on this cost-cutting combination. A letter or phone call will bring it to you.

Since 1914—leader in the field

PARKER RUST PROOF COMPANY
2173 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE corrosion resistant paint base

BONDERITE and BONDERLUBE aids in cold forming of metals

PARCO COMPOUND rust resistant

PARCO LUBRITE wear resistant for friction surfaces

TROPICAL heavy duty maintenance paints since 1883

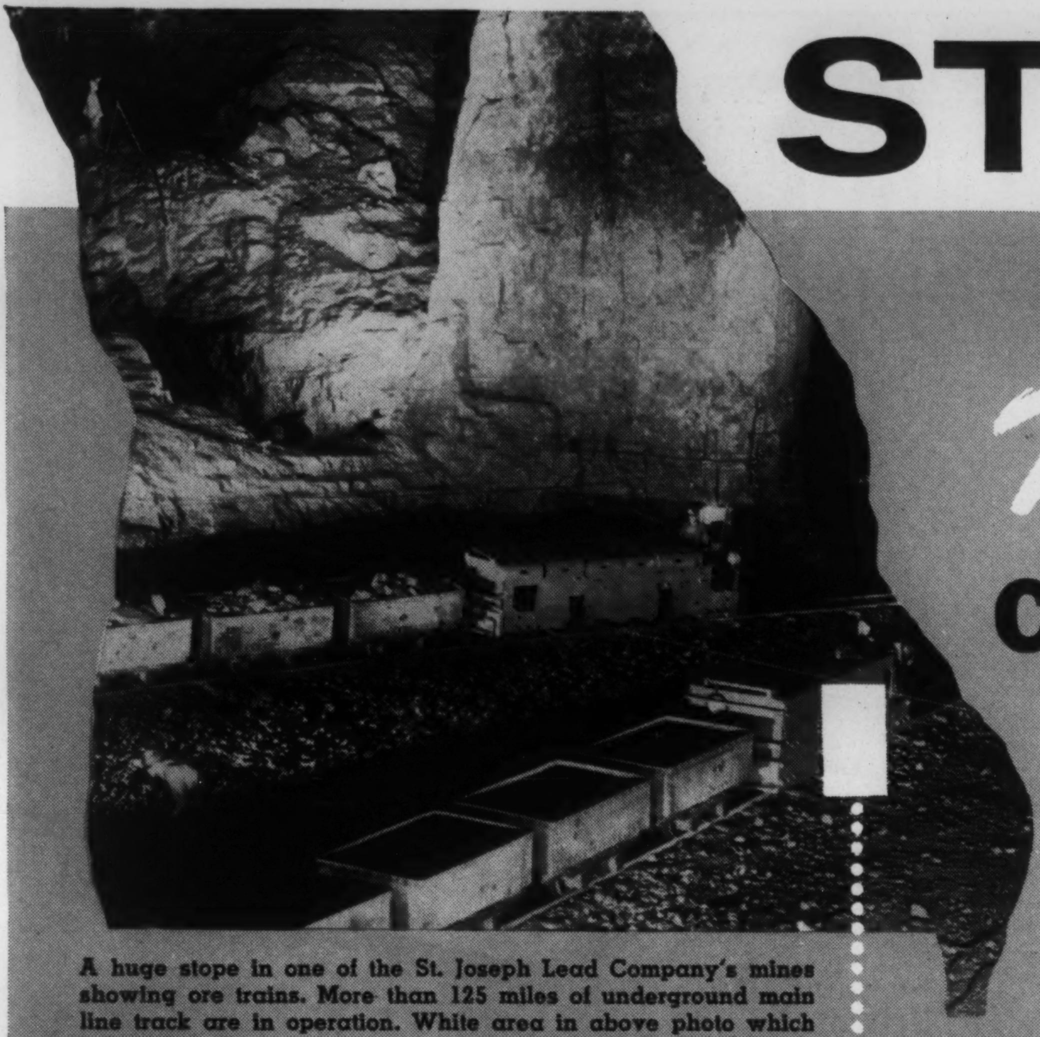
**Bonderite, Bonderlube, Parco, Parco Lubrite, Parker Pre-Namel—Reg. U.S. Pat. Off.*

For more information, turn to Reader Service card, circle No. 474

ST. JOE

The ONLY *Natural* CHEMICAL LEAD

combines a lower creep rate with greater corrosion resistance than lead produced from any other ores to which copper has been added



A huge stope in one of the St. Joseph Lead Company's mines showing ore trains. More than 125 miles of underground main line track are in operation. White area in above photo which has been silhouetted in the shape of the state of Missouri, indicates lead belt location.

According to the American Society of Testing Materials "Chemical Lead has been used for many years in the trade to describe the undesilverized lead produced from South East Missouri ores".

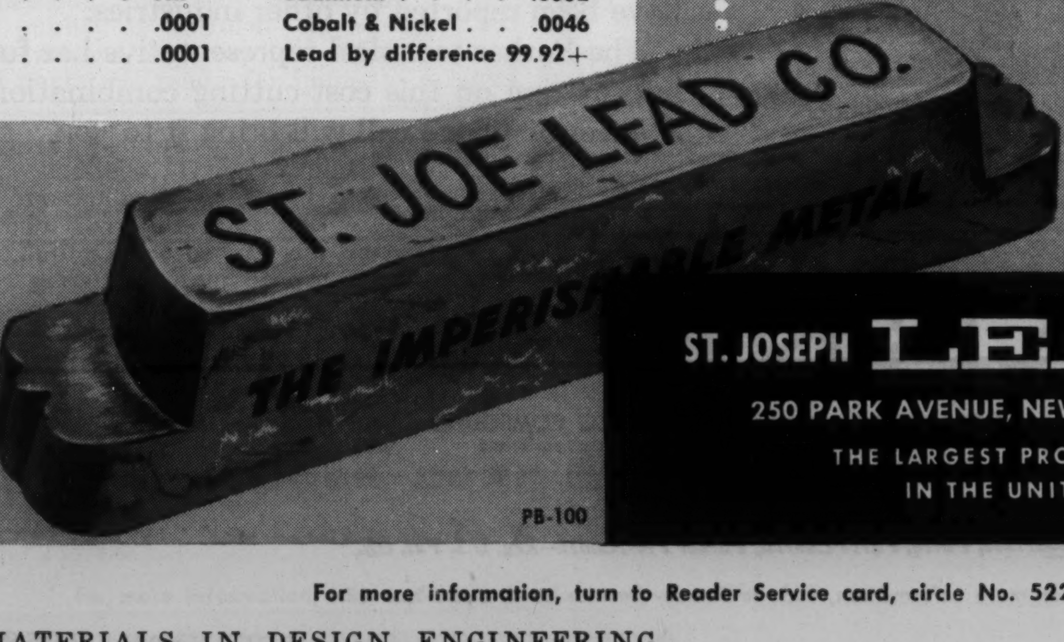
The huge ore bodies of South East Missouri from which St. Joe Chemical Lead has been produced continuously by this company since 1865 early became known as chemical lead owing to the unusual properties which it possesses. As can be seen from the analysis, it contains certain percentages of copper, silver and nickel. These elements—*which have not varied, quantitatively, for over ninety years*—combine to render the metal particularly immune to corrosive attack, give it an extremely low creep rate under steady stress and a high resistance to fatigue failure.

This combination of advantageous properties — unique in St. Joe "natural" copper-bearing lead—is also responsible for the fact that more pipe and sheet have been manufactured from St. Joe Chemical than from any other brand of lead.

TYPICAL ANALYSIS OF ST. JOE CHEMICAL LEAD

Silver	.0100%	Arsenic-Antimony-Tin Combined	.0002%
Copper	.06	Cadmium	.0002
Bismuth	Nil	Cobalt & Nickel	.0046
Zinc	.0001	Lead by difference	99.92+
Iron	.0001		

Do as others do—
Specify ST. JOE
the Natural
CHEMICAL LEAD

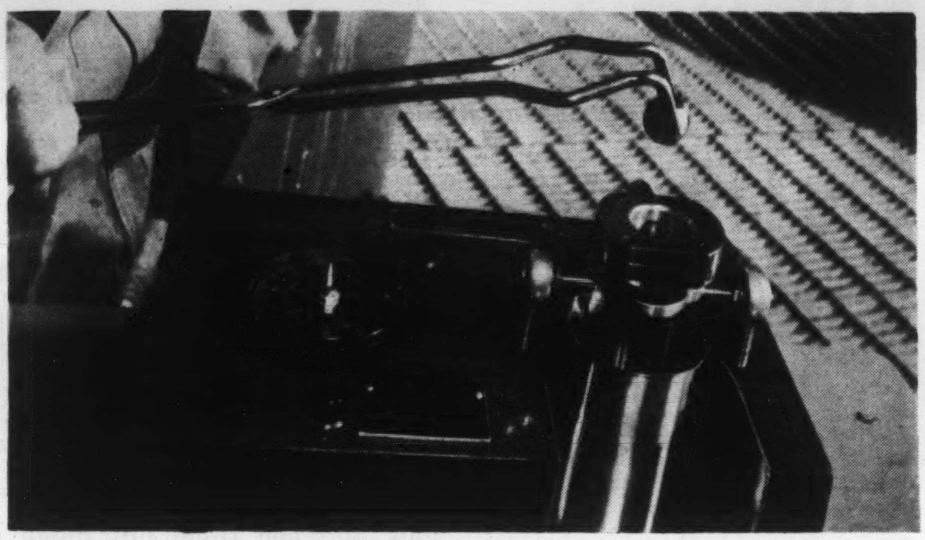


PB-100

ST. JOSEPH LEAD COMPANY
250 PARK AVENUE, NEW YORK 17, NEW YORK
THE LARGEST PRODUCER OF LEAD
IN THE UNITED STATES

For more information, turn to Reader Service card, circle No. 522

News OF INDUSTRY



Magnetic quenchometer—The simple device shown above promises to be of considerable value in accurately determining the cooling or quenching effectiveness of oils, water, brines, or other liquids used in the heat treatment of steel. The testing unit, developed by General Motors Corp., utilizes the magnetic properties of metal to compare various quenching rates of these liquids. Here's how it works:

Any magnetic material loses its magnetism when heated beyond a certain temperature (Curie point), then regains it when cooled below this temperature. Suppose a 1-in. ball of high purity nickel is heated to 1600 F (about 1000 F above the Curie point) and then dropped into a little cage suspended in a cup of the quenching medium under test. When the ball cools to the point where it regains its magnetism, it is attracted toward a magnet adjacent to the container and carries with it the cage in which it is suspended. A timing circuit is arranged to give an accurate time measurement from the instant the ball drops into the cage until it is attracted to the magnet. The interval is a measure of the cooling ability of the quenching fluid.

New Lab to Study Die Casting

A new research facility for fundamental study of the die casting process has recently been completed by Aluminum Co. of America. The laboratory, located in Chicago, is equipped for full-scale pilot plant operations which enable studies to be made under production conditions.

Work at the new laboratory is expected to result in improved quality and expanded use of die castings for such things as decorative trim and functional automotive applications, electronic and business machines, appliances, portable tools and internal combustion engines.

Heat Energy Converted into Electrical Energy

Direct conversion of heat energy into electrical energy has been successfully achieved in a unique electronic device developed at General Electric Research Laboratories.

The new thermionic converter, invented by Dr. Volney C. Wilson, takes advantage of the fact that electrons can be "boiled out" of a hot metal surface and then used to produce an electric current. Thus far, experimental converters have been successful in changing more than 8% of applied heat energy into electric power, as compared to presently used thermocouples whose efficiencies are normally well below 1%.

Briefly, this is how the converter works: A thermionic converter is a device in which a hot electrode emits electrons and a somewhat cooler electrode collects them. The collected electrons can then be sent through an external circuit. However, because of the "space-charge effect," the great number of electrons leaving the white hot emitter tend to be repelled by themselves before reaching the cooler electrode. To get around this problem, an ionized gas (positively charged particles) is placed in the space between the electrodes. The positively charged particles cancel out the effect of the negatively charged electrons and allow some of them to flow unimpeded to the cooler collector electrode. The electrons are made to perform work in an external

For more information, turn to Reader Service card, circle No. 409

Lucite
Plexiglas
Acrylic
Acetate
Butyrate
Cast Phenolic
Epoxy Resin
Ethyl Cellulose
Kel-F
Laminated Bakelite
Nylon
Polyethylene
Styrene Copolymers
Teflon
Balls
Bobbins
Bushings

NOW!
ACE
helps you get
FABRICATED
PLASTIC PARTS
faster...at lowered costs

Collars
Detents
Finials
Grommets
Handles
Knobs
Mechanical Checks
Name Plates
Pins
Plates
Plugs
Rings
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Spools
Stands
Strips

Sizes:
1/8" to 2 1/4"

Lengths:
1/16" to 9"

New e-x-p-a-n-d-e-d production facilities now give you ACE HIGH QUALITY on all types of *screw machine, centerless ground parts* and *special shapes . . . all colors . . . all materials.*
Write, wire, phone for samples, prices and bulletin listing stock items. Send specifications or blueprints for prompt quotations on specials.

ace PLASTIC COMPANY
EXTRUSION MOLDERS AND FABRICATORS
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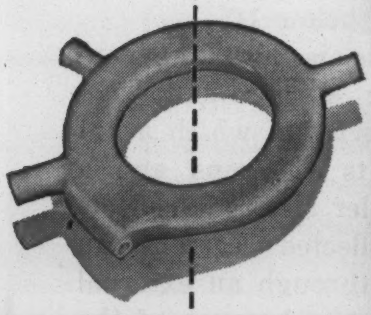

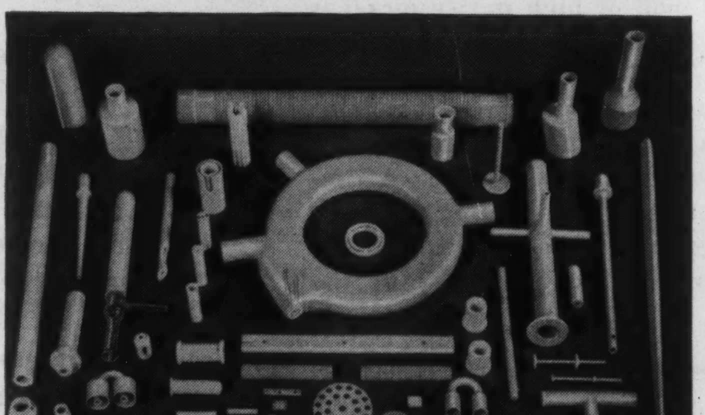

McDANEL
CERAMICS

may be
your
ANSWER

Heat, abrasion, corrosion, chemical action, or other deteriorating factors present on your project? McDanel specially-developed ceramics could be the answer. Scientists, physicists, research and development engineers are applying McDanel ceramics to a wide variety of difficult applications with good success. Our engineers develop special dies, designs, even new processes to suit your particular need. Try ceramics.

McDANEL Industrial CERAMICS

McDANEL
REFRACTORY PORCELAIN COMPANY
BEAVER FALLS · PENNSYLVANIA

Let us study a sketch of your application. Your inquiry is special to us.

For more information, turn to Reader Service card, circle No. 384

Thermionic converters *change heat energy into electricity.*

circuit and then brought back to the hot electrode.

One major difference between the thermionic converter and the thermocouple is that the metals are separated by a gas at very low pressure; there is an electrical flow between them but much less flow of heat than would be present if the metals were connected. As a result, electrodes can be at different temperatures, and efficiency is greatly increased.

According to Dr. Wilson, the electrode materials are not critical and any one or combination of several metals may be used. Molybdenum is used quite often because of its high temperature resistance.

Dr. Guy Suits, GE vice president and director of research, says the new discovery has "opened the door to new understanding of how electricity can be generated directly from heat without using machines with moving parts." It is hoped that thermionic converters may ultimately be able to change more than 30% of heat energy directly into electricity.

Theory of Magnetism Found To Be Faulty

A recent discovery by Ford Motor Co. scientists concerning magnetic properties of metals at

For more information, turn to Reader Service card, circle No. 378

ANNOUNCING

2 new Porous Ceramic Bodies

Here's the answer to a need for not one . . . but TWO new porous ceramic bodies which permit a wide latitude of material application.

1 **VAPORLAIN . . .** for applications where it is necessary to retain moisture for gradual release. Made from a special clay that is highly porous yet strong enough to retain its molded shape. Available unglazed or glazed in a variety of colors.

2 **#7023 CAPILLARY BODY . . .** an unusual ceramic composition having low thermal expansion and a uniform distribution of relatively large pores. Excellent for rapid filtering of gases or liquids. Write for additional details. Ask for Catalog 57 and allied engineering data.

the STAR
porcelain company, 34 Muirhead Avenue, Trenton 9, N.J.

California Representative:
Edwin E. Starr, 4101 Rhodes Ave., North Hollywood, Calif., STanley 7-5879

WECKESSER
CABLE CLIPS

of all nylon....
for high heat or other severe conditions

of ethyl cellulose...
for maximum economy in average conditions

Light weight, strong, chemically resistant. No short circuits, no grounds, no corrosion, no rust. Only one fastener needed Sizes to 1¼ inches. Write for free samples and price sheet.

WECKESSER COMPANY
5713 NORTHWEST HWY., CHICAGO 30, ILL.

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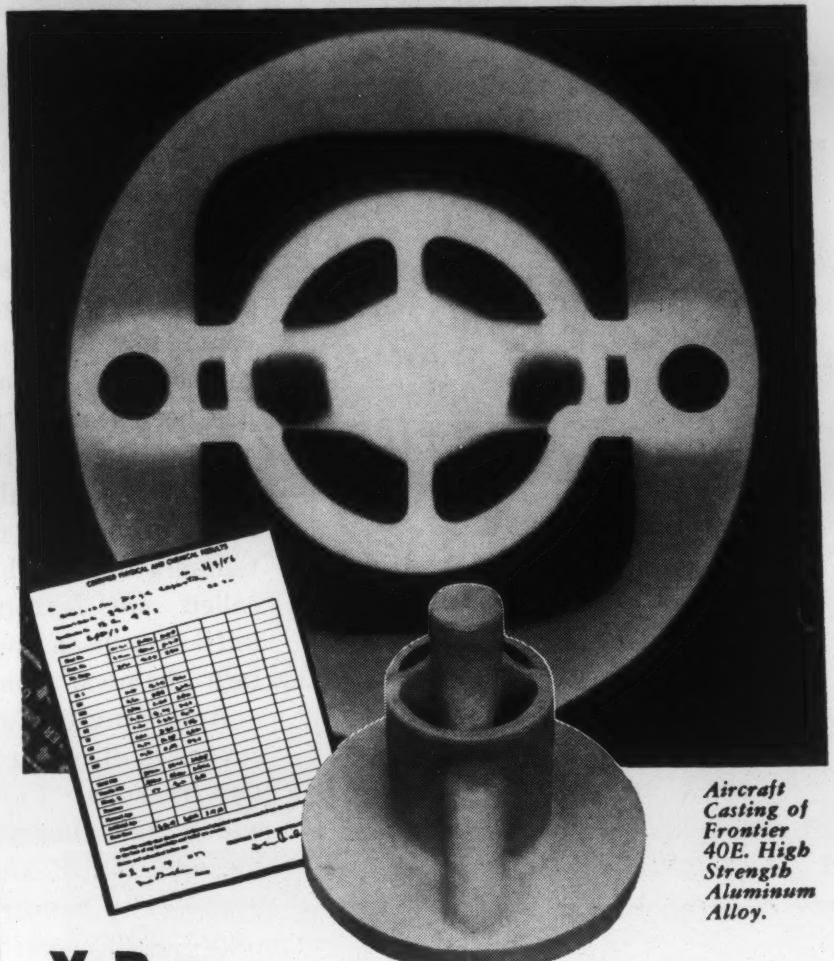
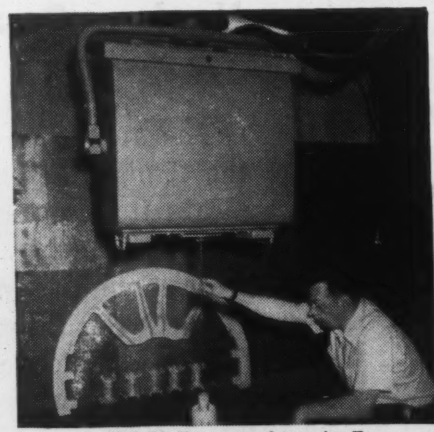
FRONTIER CASTINGS of
Aluminum • Copper • Bronze
HAVE NO HIDDEN SECRETS



Aircraft Casting of Frontier 40E. High Strength Aluminum Alloy.

X-Ray
Negative and Spectrograph Analysis furnished with each casting
(IF REQUESTED)



250 KV X-Ray machine in Frontier Lab. Penetrates 2" of bronze —6" of aluminum.

DANGER
X-RAY

Controls for X-Ray Machine. Operated from panel outside of X-Ray Room.

Quality Control at Frontier means completely controlled by Frontier. We have our own modern facilities for every phase of chemical and physical testing. Our X-Ray Laboratory is certified by the U. S. Air Corps, which certification is accepted by all branches of the government. The Frontier foundry follows the newest casting and coremaking techniques. Heat treating and rough machining facilities are also available.

For complete information write to the originators of Frontier 40-E the high strength aluminum alloy.

FRONTIER BRONZE CORP.
4874 PACKARD ROAD, NIAGARA FALLS, NEW YORK

Exclusive Foreign Producers of 40-E
DARALUM CASTINGS LTD., DARLINGTON, ENGLAND
PAUL BERGSOE & SON, GLOSTRUP, DENMARK
L'ALUMINUM FRANCAIS, PARIS, FRANCE

For more information, turn to Reader Service card, circle No. 362

how to
CUT
COSTS
on small
components

If the cost of metal stampings and wire forms figures in your profit picture, let us give you a quotation on your current components. Send us a sample or blueprint . . . and discover how big savings in time and production costs, big gains in precision and uniformity are possible on small components, when Art Wire tackles the job!

Our engineering staff, our production experience, and our modern high speed equipment are always at your disposal. If you wish to learn more about what a wide and versatile range of shapes and parts we can produce for you—at lower cost than you'd guess—just write for our illustrated folder.

ART WIRE AND STAMPING CO.

13 Boyden Place, Newark 2, N. J.

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low temperatures may prove to be a missing link in the study of magnetism and may lead to revision of science textbooks. Theories of magnetism have always held that all magnetic metals become more magnetic when their temperature is lowered. Now it has been learned that the reverse can be true: adding aluminum to iron creates an alloy whose magnetic properties decrease at low temperatures. This phenomenon, called anti-ferromagnetism, has until now been found only in certain chemical compounds.

According to Ford, the new discovery is of major significance for two reasons: 1) it disproves a widely held theory, and 2) because the addition of aluminum to iron produces a noncorrosive alloy, it suggests the possibility that there may be a close relationship between rusting and magnetism.

The research was done by Anthony Arott and Hiroshi Sato.

Nuclear Congress To Be Held in March

The atomic energy industry of the United States will demonstrate its progress in the use of nuclear energy at the 1958 Nuclear Congress, to be held Mar 17-21 at the International Amphitheatre, Chicago. This year's Congress, sponsored by more than 30 engineering and scientific societies, is expected to be the largest assembly ever held on nuclear energy. The four major conferences to be held and the areas covered by each are summarized below:

1. Nuclear Engineering and Science Conference. A total of 150 papers will review late developments in atomic energy applications, including aircraft propulsion.

2. Atomic Industrial Forum. This year's Forum will feature

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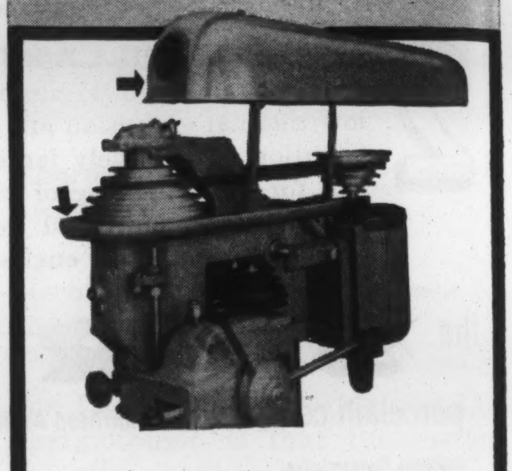

It's a top guard for a drill press

This guard and its matching guard pan must be impact resistant . . . corrosion resistant . . . unaffected by temperature variqtions.

MOLDED FIBER GLASS was chosen not only because it meets these requirements, but also because it *costs less*. Tooling costs alone for MOLDED FIBER GLASS are considerably lower than for drawn steel, which was also under consideration for this use.

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THE GREATEST NAME MOLDED FIBER GLASS IN REINFORCED PLASTICS

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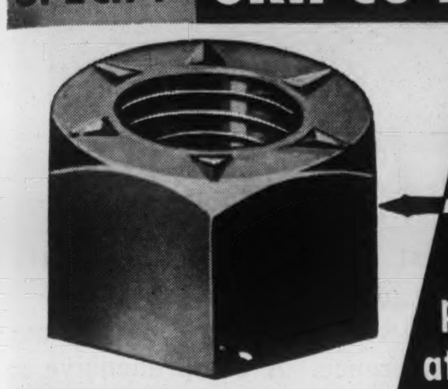
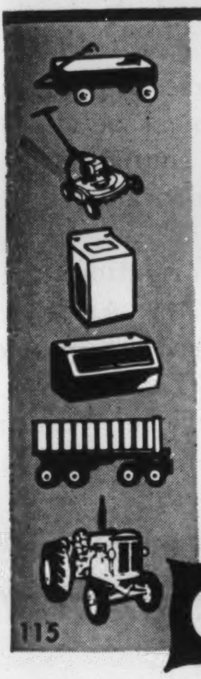


to resist stress, wear and vibration

They increase product durability at low initial cost



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- We have made more complex extrusion dies than anyone we know.
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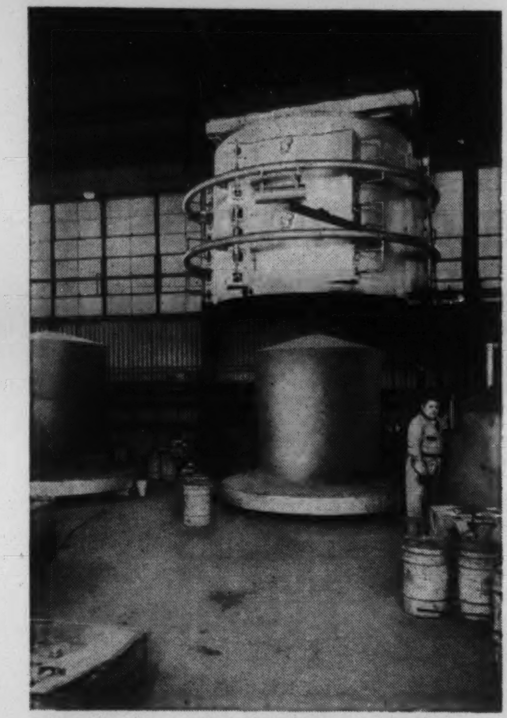
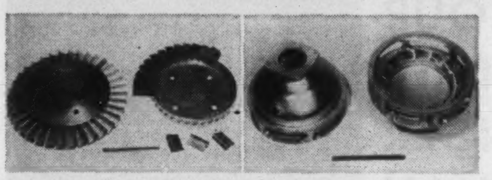
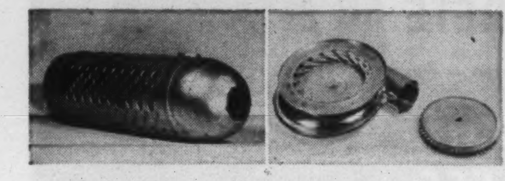


The 72-inch dia. hydrogen atmosphere furnace being lowered over a loaded furnace bell. Detroit plant.



Brazed stainless steel and titanium alloy parts are strong, undistorted, and bright and free of oxides.



If you are planning the manufacture of stainless alloy assemblies, you should check our facilities and skills for

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You'll find our up-to-the minute facilities and years of experience can help you in your stainless steel brazing and heat treating. All three of our plants are equipped with pure dry hydrogen atmosphere furnaces, and are manned by skilled engineers. They are also pioneers in the use of Nicrobraz, the stainless brazing alloys that have the strength and corrosion resistance of stainless steel at 2000° F.

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THE WORLD'S STANDARD OF HARDNESS TESTING ACCURACY

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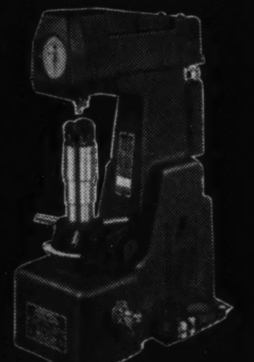

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News OF INDUSTRY

latest developments in industrial uses of atomic energy.

3. Atomic Energy Management Conference. A comprehensive review of progress made to develop low cost nuclear power.

4. Hot Laboratories Equipment Conference. Technical details of the development of equipment and the operation of laboratories for atomic energy.

For further information, contact either Joel Henry, American Institute of Chemical Engineers, 25 W. 45th St., New York 38, N.Y., or J. Earl Harrington, Western Society of Engineers, 84 E. Randolph St., Chicago, Ill.

(News of Engineers on p 234)

12-ft measuring machine—Pictured here is the latest Pratt & Whitney measuring machine, said to be the largest of its kind made for use in the manufacture of jet aircraft. Essentially, the 144-in. measuring machine consists of a master bar, measuring head and Electrolimit tailstock—all mounted on a seasoned rigid bed. The master bed is made in three sections and has 144 stainless steel measuring bar buttons. Each button carries a finely drawn hairline—exactly 1 in. from button to button. The hairline is visible through an attached 75 power microscope and is used for setting each inch of length according to the length required on the part to be inspected.

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Effective deoxidizer and cleanser for medium and high carbon steels.

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Deoxidizer and cleanser with less increase in carbon content of the steel.

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For Alloy steel with a residual titanium content.

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Deoxidizer, grain refiner and graphitizer for cast iron.

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Titanium source in aluminum or master aluminum alloys.

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Zirconium source in special alloys.

Titanium Carbide

Component in sintered cutting tools, jet engine parts, refractory material, abrasives.

Zirconium Cyanonitride

Zirconium for Zirconium Tetrachloride and for process metallurgical applications.

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Efficient alloying of zirconium with magnesium.

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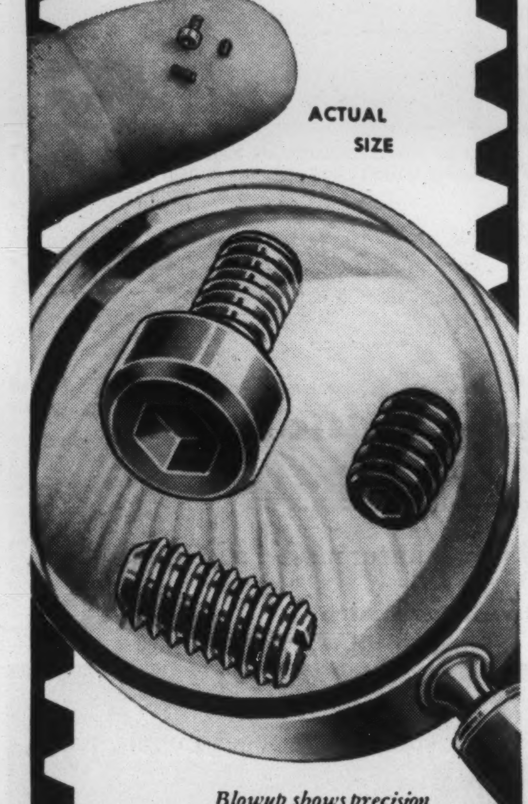
FREE TEST SAMPLES
Show How
MINI-MITE
miniaturized
SET SCREWS
CUT YOUR COSTS!



Blowup shows precision made MINI-MITESet Screws with perfectly formed heads which asssure easy insertion of driving tools.

For miniaturized applications Setko MINI-MITE Set Screws can cut your costs in four important ways. *Reduces initial cost,* no extra charges are incurred because of special design. *Increases production rates* because MINI-MITES are made with watch makers precision, threads mesh precisely — insert perfectly. *Cuts down on rejects* in sub or final assembly because of consistent uniform quality. *Immediate availability* in Slotted, Socket and Socket Cap types in sizes #0, #1, #2 and #3 and in a wide selection of metals, finishes, lengths and points to choose from.

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describing the complete Setko line.

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SET SCREWS

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News OF INDUSTRY

Engineers

Alvin J. Jones has been appointed director of engineering, Motch and Merryweather Machinery Co.

Joseph S. McVey, Jr., has been appointed casting design engineer, Foundry Dept., General Electric Co.

Dr. C. D. W. Thornton has been named director of research and development, Farnsworth Electronics Co.

Dr. A. M. Adsoy has been appointed manager of Crucible Steel Co. of America's new applied research lab-America's new applied research Laboratory.

Howard D. Hatough is now general manager of the Girdler Catalyst Dept., National Cylinder Gas Co.

William Staecker is assistant manager of engineering, Press Div., E. W. Bliss Co. **Alfred Drain** replaces Mr. Staecker as chief engineer of the Canton Div.

T. A. Haller has been elected vice president in charge of engineering, a newly created position at J. I. Case Co.

Dr. William H. Bowman has been appointed general manager and **Neil B. Bowman** has been named assistant general manager of the Organic Chemicals Div., American Cyanamid Co.

Robert L. Grunewald has been appointed manager — manufacturing, Gas Turbine Dept., General Electric Co.

Samuel E. Tyson has been appointed metallurgist, stainless steels, Carpenter Steel Corp.

Dr. Kenneth Bock has been appointed director of research, National Malleable and Steel Castings Co.

P. H. Spennetta, former chief of research and testing at Caterpillar Tractor Co., has joined the engineering staff of J. I. Case Co. as director of engineering for the Industrial Div.

Dr. David Bandel has been promoted to associate technical director, Tracerlab, Inc. Dr. Bandel's predecessor,

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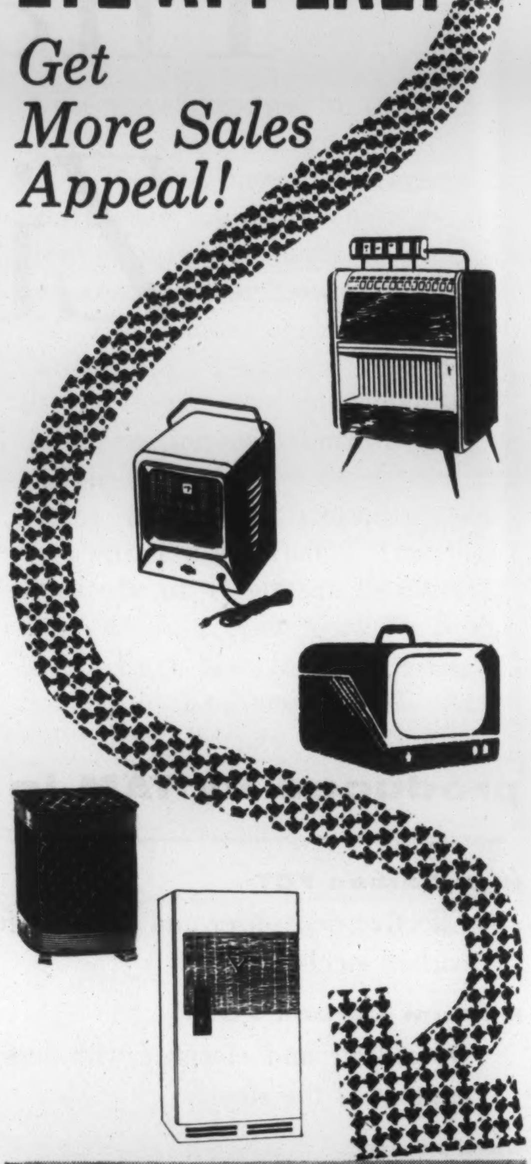

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*"Mylar" is DuPont's registered trade mark for its brand of polyester film.

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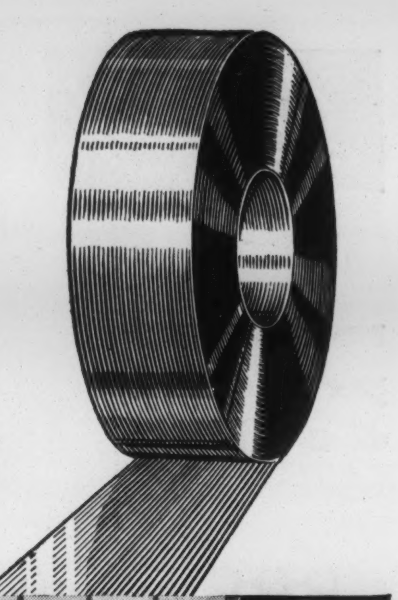
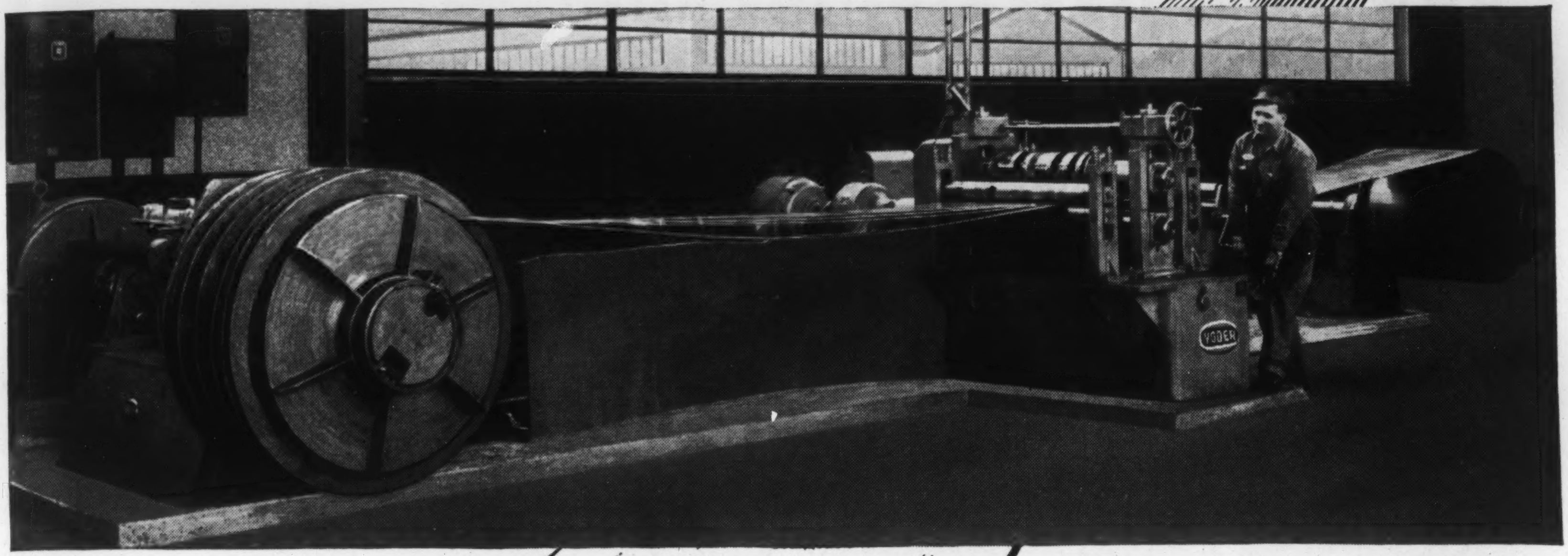
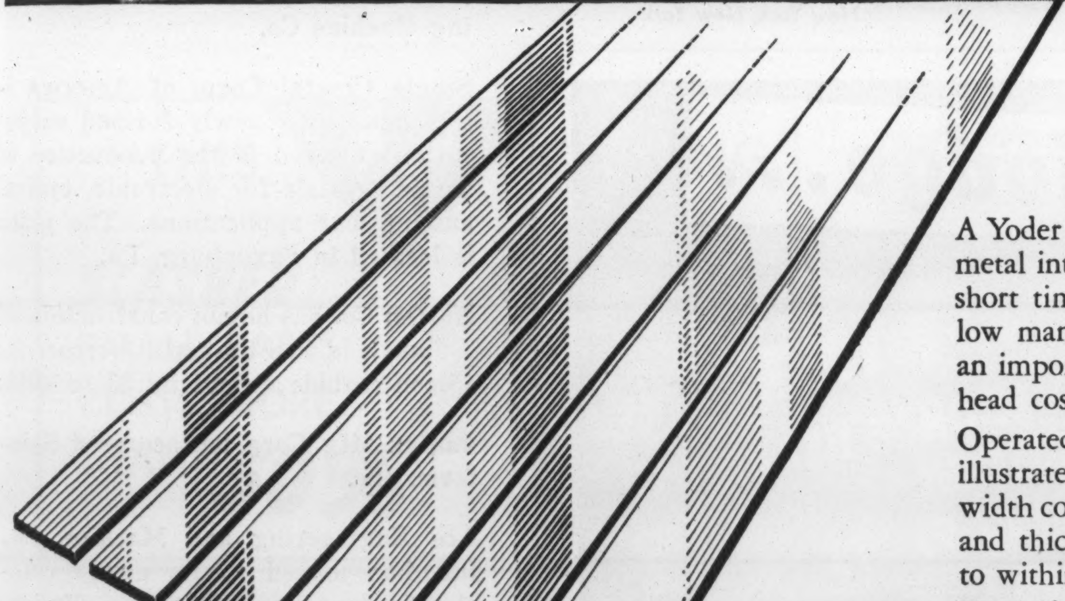


from cold strip to slit strands
IN SECONDS...
with a YODER
ROTARY MULTIPLE SLITTER





A Yoder slitter converts mill-width coils of flat-rolled metal into many variable-width strands in amazingly short time. Speed, coupled with great accuracy and low manpower requirements, makes a Yoder slitter an important factor in keeping production and overhead costs down.

Operated by only two men, the Yoder Type 3-48 slitter illustrated is designed to accommodate standard mill-width coils up to 48 inches wide, in a variety of metals and thicknesses. The slit strand widths can be held to within a .004" tolerance.

Even if your steel requirements are as little as 100 tons a month, the savings to be realized in time, manpower and raw material costs alone will pay for a Yoder slitter in the first few months of operation.

There is a Yoder slitter designed and engineered to meet your requirements, and to speed the delivery of "special" width stock in a wide range of large or small sizes. Send for your free copy of the fully-illustrated, 76-page booklet, "Multiple Rotary Slitting Lines."

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ROTARY SLITTING LINES
PIPE AND TUBE MILLS (ferrous or non-ferrous)
COLD ROLL FORMING MACHINES

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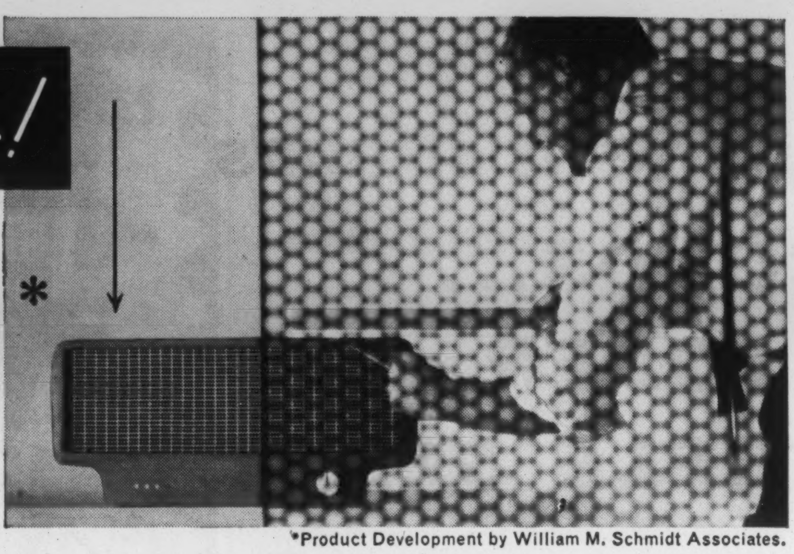
Idea!

mock-up projects design



*Product Development by William M. Schmidt Associates.

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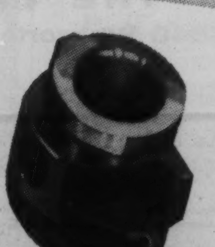

THE American Crucible PRODUCTS CO.

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News OF INDUSTRY

Dr. William Tittle, left Tracerlab to accept a full professorship at Southern Methodist University where he will develop a program on reactor engineering.

Companies

Gibson Electric Co. has moved its manufacturing facilities and offices to a new 26,000-sq ft building in Delmont, Pa.

Calumet Steel Div., Borg-Warner Corp., has completed plans for a multimillion dollar expansion of its facilities in Chicago Heights, Ill.

George Rattray & Co., Inc. is now a wholly owned division of **Hardwick, Hindle, Inc.,** a subsidiary of American Seal-Kap Corp.

Budd Co. has purchased **Krouse Testing Machine Co.**

Single Crystal Corp. of America is the name of a newly formed corporation engaged in the production of single crystals for electronic, optical and nuclear applications. The plant is located in Saxonburg, Pa.

Norton Co. has begun construction of a plant addition that will increase its silicon carbide output by 25 to 40%.

Pantex Mfg. Corp. has acquired **Spinform, Inc.**

Ace Engineering and Machine Co., Inc. has moved to its newly completed plant at Huntingdon Valley, Pa.

Spencer Chemical Co. has opened a new research center in Kansas City, Mo.

Ogden Corp. has acquired **Eimco Corp.** and **American Foundry Machine Co.**

Hess, Goldsmith & Co., Inc. has acquired all of the machinery and equipment of **Wishahickon Asbestos Co.**

Morningstar, Nicol, Inc. has acquired **Federal Adhesives Corp.**

Borden Co. has recently completed a new plant at Illiopolis, Ill. that will

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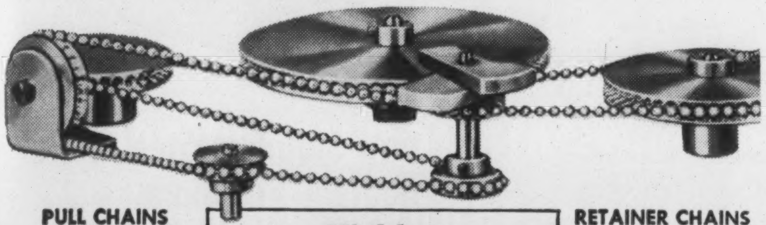
Low-Speed, Positive Drives or Motion Transfer
. . . At Far Less Cost!

NOW—BEAD CHAIN—QUALIFIED FOR DRIVES

Swivel-like Bead Chain and special non-slip sprockets make any drive possible . . . at low cost . . . eliminates expensive gears, universal joints, etc. Perfect for inaccessible locations!



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Chain of a thousand uses! Low cost, attractive, easy to use! 5 Sizes: 3/32" to ⅜". Strengths 20 to 200 lbs.
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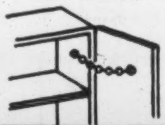

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An astute buyer and a knowledgeable OPC man worked together to affect this tremendous saving on small parts for S & C Electric Company. An equally astute buyer could call in the OPC man and quite likely make equally substantial savings on your small parts.

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109 Webb St. . . . . DAYTON 3, OHIO
Plaster Mold Castings made from
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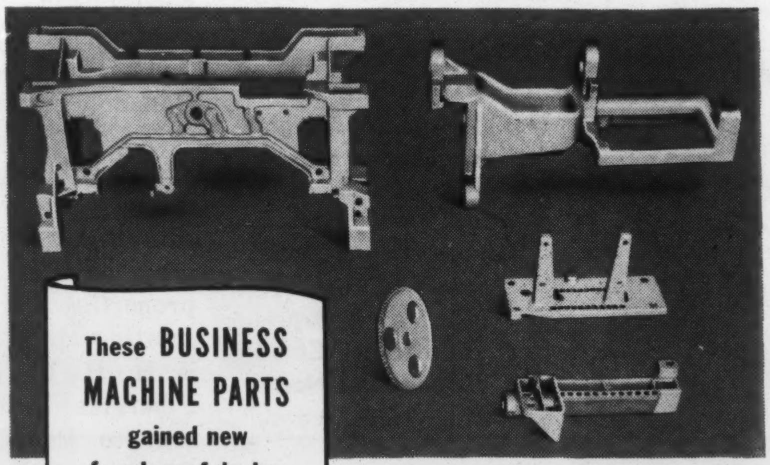

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TUBE COMPANY

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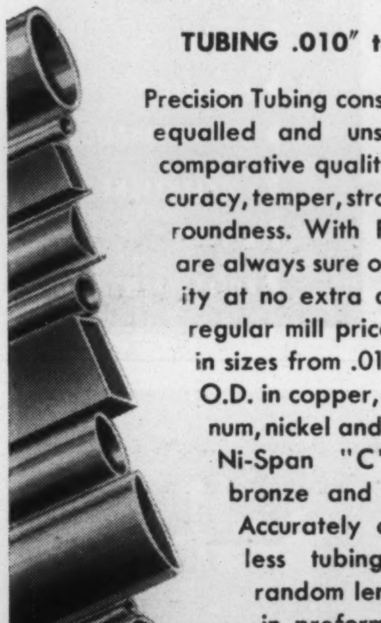


News OF INDUSTRY

triple the company's styrene-butadiene production capacity.

Celanese Corp. of America has started construction of a new manufacturing unit at Belvidere, N. J. that will substantially increase its production of polyvinyl acetate emulsions. These emulsions are used in water-thinned latex paints, adhesives, nonwoven fabrics, and for textile finishing and paper coating.

Societies

Drop Forging Assn. has reorganized its internal structure so that it will now function through five separate divisional councils. Divisions and chairmen are: Marketing and Education—Victor Brown, Kropp Forge Co.; Industrial Relations—Walter A. Frazee, Steel Improvement & Forge Co.; Engineering and Production—Louis M. Fehrenbach, Indianapolis Drop Forging Co.; Legislation and Government Relations—Victor F. Braun, Ladish Co.; and Management Aids—William A. Carlile, Columbus Bolt and Forging Co.

Electrical Insulating Materials Assn. is the name of a new organization formed for the purpose of disseminating practical information about the properties and uses of electrical insulating materials. Protem chairman is H. H. Chapman, Owens-Corning Fiberglas Corp. Inquiries may be sent to Mr. Chapman, c/o Owens-Corning, 598 Madison Ave., New York 22, N. Y.

Industrial Heating Equipment Assn. announces the election of Robert E. Fleming as vice president. He succeeds Carl L. Ipsen who is retiring.

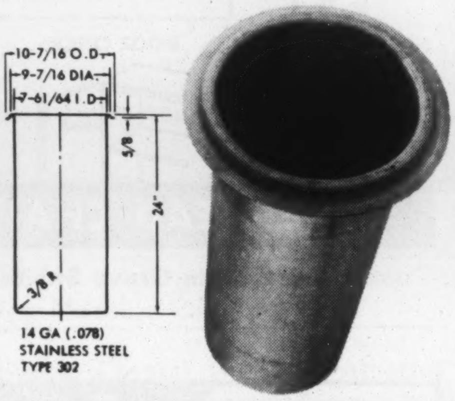
Pressed Metal Institute has elected the following 1958 officers: president—C. E. Stryker, Maysteel Products, Inc.; first vice president—Carter Higgins, Worcester Pressed Steel Co.; second vice president—Darwin W. Clay, Parish Pressed Steel Div., Dana Corp.; secretary-treasurer—Bryant Gemmill, American Stamping Co.; and assistant secretary-treasurer—Mel Lorentz, HPL Mfg. Co.

(News of Meetings on p 240)

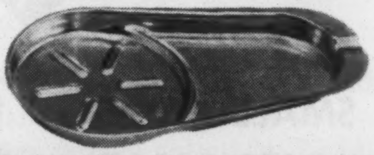
FROM 17,000
Gallon refrigerated
Stainless Steel Tanks

TO
tiny Stainless Steel
floats 1" in diam.
weighing only 1 oz.

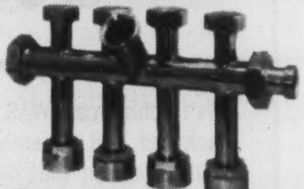
FROM extremely deep, complex, one piece draws in Stainless

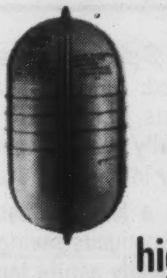


TO high production draws for small parts



FROM complicated tubular fabrication in Stainless Steel





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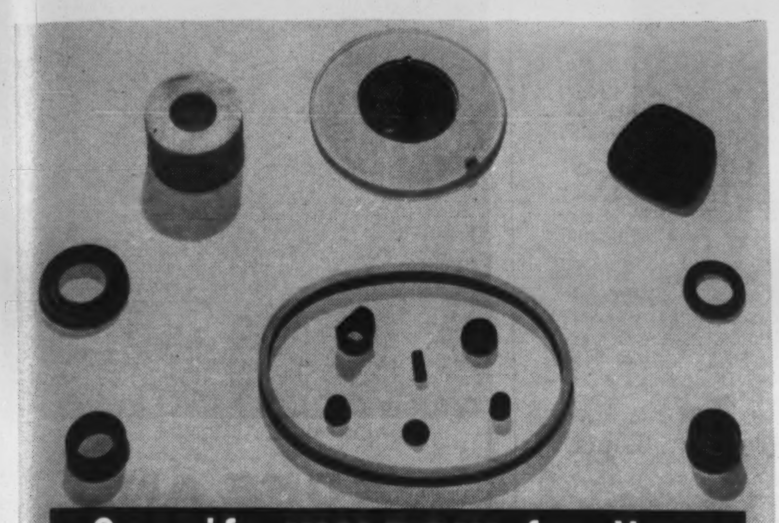

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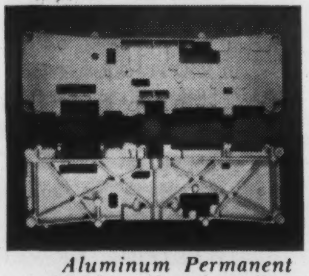

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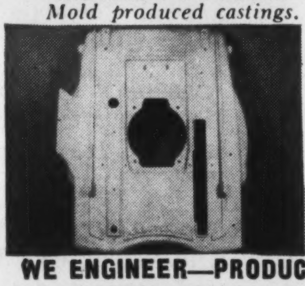

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STRAITS TIN REPORT

MALAYAN TIN BUREAU

New developments in the production, marketing and uses of tin

The new atomic power plant at Shippingport, Pa., has more than 58 miles of condenser tubes. They're made of an alloy containing from 0.9% to 1.2% tin.

★ ★ ★

Tests show that a new tin-cadmium alloy plating has greater corrosion resistance to salt spray, jet fuels, high temperature synthetic oils, and organic acid vapor than cadmium plating alone. It can be soldered the same way—and just as easily—as standard cadmium plated coatings.

★ ★ ★

Malaya has been the world's largest producer of tin for many years—over two-thirds of the tin consumed in this country is produced there. Yet, according to an official assessment, there is still as much tin left in the ground as has thus far been taken out.

★ ★ ★

A British firm recently developed a new solder paint for hot tinning or soldering stainless steel. The solder is simply painted on the steel and then heated to normal soldering temperature. Tin content ranges from 40% to 100% in the three grades manufactured.

Ask us to send you TIN NEWS, a monthly letter. It will keep you posted on tin supply, prices, new uses and applications.

The Malayan Tin Bureau
Dept. 24B, 1028 Connecticut Ave., Washington 6, D.C.

For more information, circle No. 390

News OF INDUSTRY

Meetings

AMERICAN SOCIETY FOR TESTING MATERIALS, committee week. St. Louis. Feb 9-15.

INSTITUTE OF RADIO ENGINEERS, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, INSTRUMENT SOCIETY OF AMERICA AND CLEVELAND PHYSICS SOCIETY in cooperation with CASE INSTITUTE OF TECHNOLOGY and WESTERN RESERVE UNIVERSITY, 5th annual Cleveland electronics conference. Cleveland. Feb 14-15.

AMERICAN INSTITUTE OF MINING, METALLURGICAL AND PETROLEUM ENGINEERS, INC., annual meeting. New York City. Feb 16-20.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Gas Turbine Power Div., conference and exhibit. Washington, D. C. Mar 2-6.

CLEVELAND ENGINEERING SOCIETY, 15th annual machine design conference. Cleveland. Mar 3.

INSTRUMENT SOCIETY OF AMERICA, eighth annual conference on instrumentation for the iron and steel industry. Pittsburgh. Mar 11-13.

SOCIETY FOR NONDESTRUCTIVE TESTING, conference on "Practical Applications of Radiographic Testing." Westbury, L. I., N. Y. Mar 12.

AMERICAN ROCKET SOCIETY and AMERICAN SOCIETY OF MECHANICAL ENGINEERS, joint aviation conference. Dallas, Tex. Mar 17-20.

STEEL FOUNDERS' SOCIETY OF AMERICA, annual meeting. Chicago. Mar 17-18.

NATIONAL ASSN. OF CORROSION ENGINEERS, annual conference. San Francisco. Mar 17-21.

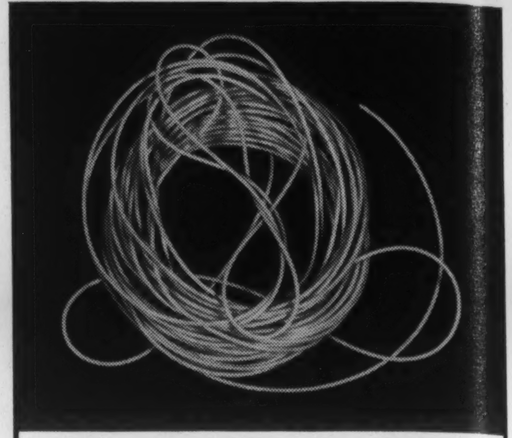
SOCIETY OF THE PLASTICS INDUSTRY, 15th annual Pacific Coast section conference. Palm Springs, Calif. Mar 26-28.

Design Engineering Conference, American Society of Mechanical Engineers, Machine Design Div. Chicago. Apr 14-17.

Design Engineering Show. International Amphitheatre, Chicago. Apr 14-17.

AMERICAN WELDING SOCIETY, welding show. St. Louis. Apr 14-18.

METAL POWDER ASSN., annual meeting and powder metallurgy show. Philadelphia. Apr 21-23.



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Reynosol is being successfully used today for a wide variety of rope and wire coatings. Reynosol permits adhesion between rope fibers and offers the added advantage of bonding fibers.

GENERAL SPECIFICATIONS

COLOR	UNLIMITED
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AGING PROPERTIES	GOOD
COLD PROPERTIES	FLEXIBLE AT 65° F
LIGHT RESISTANCE	GOOD
TYPE OF SURFACE	DRY AND GLOSSY
TENSILE STRENGTH	VERY GOOD
SCUFF RESISTANCE	VERY GOOD
ABRASION RESISTANCE	VERY GOOD
ALKALI RESISTANCE	VERY GOOD
ACID RESISTANCE	VERY GOOD
OIL RESISTANCE	VERY GOOD
HARDNESS	AS HIGH AS 80 (SHORE-A)
% FILM COATING	95% to 100%
FIRE HAZARD	NONE

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THE LAST WORD

by **H. R. Clauser**, *Editor*

Integration, Not Segregation

In *One Point of View* this month (p 103) we take the position that we need more and better science education for the non-scientist. Here we'd like to mention another important need of modern education—the need for closer integration of the teaching of science and the humanities. It is still too widely held that these two great areas of human knowledge are opposites, and as Dr. Killian, president of MIT and the new missiles director, has said, it is the responsibility of our colleges to stress the kinship of all knowledge. As he put it: "We need . . . to develop more sensitive couplings interconnecting the sciences . . . and the humanities . . . The liberal arts of our time cannot be liberal if they reject or disdain science or technology . . . [and] science and technology . . . [cannot] fulfill their responsibilities if our scientists and engineers lack the humanistic quality."

Switcharoo

During the meeting of the American Society of Mechanical Engineers last December, recruiters weren't the only ones who took hotel rooms to conduct employment interviews. Fourteen unemployed engineers also rented a room at the Statler and made themselves available for job offers. They had been laid off the previous month for lack of work at Curtiss-Wright Corp. While patiently awaiting offers, the group received a number of phone calls asking for resumes and more information. Also a few interviews were arranged. But no one was hired. Who said there is a shortage of engineers?

The Life of a Rat

Rats have a tough life. As our benefactors, they are shot into space, driven crazy in mazes, and killed in medical experiments. As pests, they are trapped, poisoned and deprived of food in as many ways as we can think of. Now, the latest threat to their existence comes from the Dept. of the Interior's Branch of Predator and Rodent Control. The experts there have developed a series of rodent repellents for adding to plastics molding compounds. The chief purpose of the repellants is to discourage rats from eating through polyethylene garbage cans.

Immaterialisms

▶ A brand new science has recently come into being, we hear. It has been given the name of psychoceramics, and its purpose is the study of crackpots.

▶ According to a recent newspaper report, the new State Dept. building to be completed in 1960 will have among its conveniences a deluxe $40,000 incinerator. Equipped with chutes from each floor, it will be fed 7500 lb of "classified trash" every 8 hr. That figures out to about 2,000,000 lb per year. Somehow it seems wasteful to produce such an astonishing volume of secrets and then, after they have served their purpose, just burn them. Surely there must be some harmless use for worn out secrets.

▶ Seriously, the above item led me to wonder what the total cost of secretiveness has been to man. Consider the duplication of effort, alone, that has resulted from confidential technical information being withheld by both Government and private organizations throughout the world. There is no way to calculate it, but we can guess that if secrecy were unknown, people would now be spending two-month vacations on the moon.

▶ President Eisenhower recently had this to say about the importance of planning: Plans are worthless, but planning is everything.